

8-1-2018

Determination of Takeoff and Landing Distances Using an iPad Performance Application for the Diamond DA40

Tyler A. Babb

Middle Tennessee State University, tyler.babb@mtsu.edu

Christina Hiers

Middle Tennessee State University, christina.hiers@mtsu.edu

Follow this and additional works at: <https://commons.erau.edu/ijaaa>



Part of the [Aviation Safety and Security Commons](#), [Educational Psychology Commons](#), [Management and Operations Commons](#), [Science and Technology Studies Commons](#), and the [Systems Engineering and Multidisciplinary Design Optimization Commons](#)

Scholarly Commons Citation

Babb, T. A., & Hiers, C. (2018). Determination of Takeoff and Landing Distances Using an iPad Performance Application for the Diamond DA40. *International Journal of Aviation, Aeronautics, and Aerospace*, 5(4). <https://doi.org/10.15394/ijaaa.2018.1252>

This Article is brought to you for free and open access by the Journals at Scholarly Commons. It has been accepted for inclusion in International Journal of Aviation, Aeronautics, and Aerospace by an authorized administrator of Scholarly Commons. For more information, please contact commons@erau.edu.

Electronic Flight Bags (EFBs) have become standard equipment in both the commercial aviation and aviation training environments. EFBs can provide aeronautical charts, weather information, pilot logbooks, glide advisors, flight plan processing, and many other services. As EFBs gain more capabilities, they are becoming more central to flight operations. For example, cruise performance calculations are now included in some common software (ForeFlight, n.d.). Prior to approving students to use such EFB functions, flight schools should evaluate performance data generated by the EFB to verify accuracy.

At Part 121 air carriers, the hardware and software used to determine aircraft performance parameters are typically evaluated and approved by the appropriate civilian aviation authority. The approval process requires substantial testing, including all parameters and limits as identified by the manufacturer data provided in the Airplane Flight Manual (AFM). Historically, general aviation pilots have determined performance parameters on paper using the manufacturer's information in the approved AFM.

In 2017, a software developer introduced a performance application for general aviation (GA) aircraft, providing an opportunity for GA pilots to use an EFB for fast and accurate aircraft performance calculations. To evaluate this software, guidance from the Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA) was tested in a manner as if this software was used by an air carrier. Several civilian aviation authorities around the world have provided guidance to air carriers on how to achieve operational approval for the use of EFBs to calculate takeoff and landing distances. This study applied appropriate regulatory guidance to evaluate this application for accuracy, consistency and recommended human/software interface behaviors.

Research suggests that today's students now use tablet technology on a daily basis for both school and leisure. A recent study found that as many as 86% of students used tablet computers daily for educational purposes (Cassidy et al., 2014). As for aviation education, this trend may lead to the use of EFBs for more and more functions not only for ease of use but also as a student-preferred method. Effectively, E6B flight computers, sectional charts, and navigation plotters have been replaced by EFBs. If a developer can generate an EFB software that accurately determines performance data, then this could add another usable EFB function for pilots in training.

Literature Review

Many companies provide performance data for operators of transport category aircraft. One such company is Aircraft Performance Group (APG), which originally provided dispatch services to air carriers dating back to 1981 (APG, n.d.). After Jeppesen acquired APG in 1995, the company expanded services to offer performance calculations for more than 5,000 general aviation aircraft worldwide (APG, n.d.). Software developers design performance software to satisfy regulatory requirements meet the unique needs of each of their customers. As for air carriers, it is their responsibility to evaluate the software to secure operational approval for specific EFB functions from their appropriate FAA regulatory office.

The newly burgeoning market of general aviation EFB applications is also expanding to performance calculations. ForeFlight Mobile is a very popular EFB application for GA pilots and has been found to have the most usable software design when compared with competitors (Schwartzentruber, 2017). Software such as Foreflight was first used to replace sectional charts and low enroute IFR charts, but the capabilities of these EFB applications are growing. ForeFlight introduced performance calculations in 2017 (ForeFlight, 2017). The pilot can now choose a performance profile, and then the software calculates fuel burn inflight using a manufacturer's recommended power setting (Foreflight, 2017). However, ForeFlight Mobile does not yet support detailed performance parameters such as takeoff and landing distance.

Takeoff and landing performance calculations are essential skills even for student pilots. The FAA's Private Pilot Airmen Certification Standards (ACS) require that a private pilot applicant exhibit satisfactory knowledge and skills associated with operating an aircraft safely within performance limitations and manage the risk of inaccurate use of performance charts (FAA, 2017). Basic aircraft performance parameters are discussed in the FAA's *Pilot's Handbook of Aeronautical Knowledge*. This text provides pilots with instructions on how to determine takeoff distance using charts very similar to the charts used in this study.

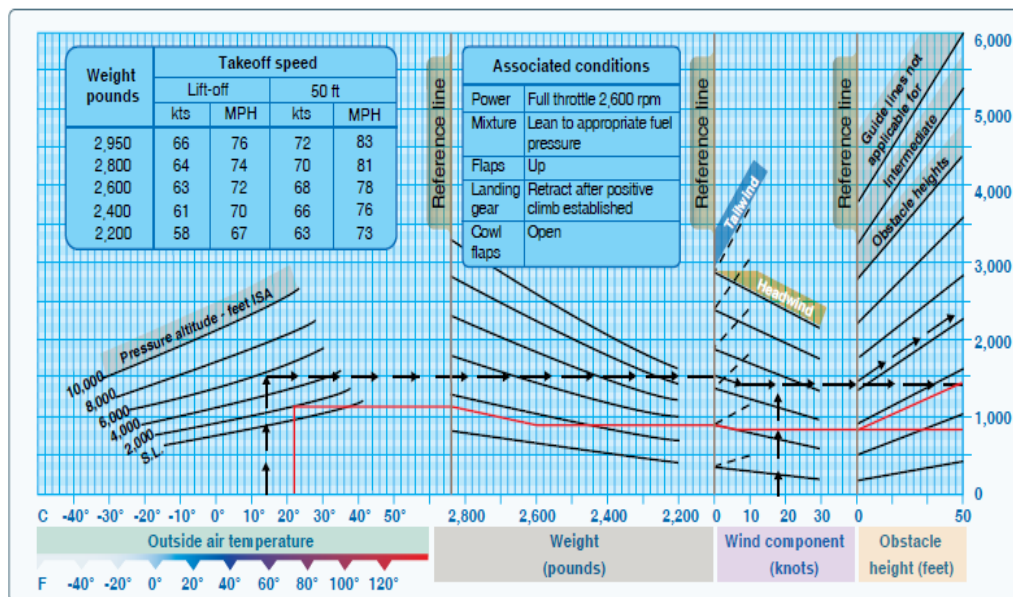


Figure 1. FAA Instructions on How to Determine Takeoff Distance (Pilot's Handbook of Aeronautical Knowledge, 2017)

When pilots calculate takeoff and landing distance, they must account for several variables. These variables include, but are not limited to temperature, pressure altitude, aircraft weight, and winds. Most data provided by manufacturers assume that for takeoff and landing distances, the runway surface is smooth, un-grooved, and dry (FAA, 2017). If the runway condition is contaminated, then these factors affect both the acceleration and deceleration capabilities of the airplane, greatly increasing distances required (FAA, 2017).

The FAA provides both the regulatory requirements and guidance on how to determine aircraft performance parameters in the United States. Federal Aviation Regulation (FAR) 91.103, titled "Preflight Action," requires pilots to determine takeoff and landing distances, as well as the runway distances available for each flight (FAA, 2018). This guidance is broad but applies to all flight operations. This requirement is directly related to safety. A pilot must ensure that there is enough runway available to takeoff or land.

The FAA provides guidance to for EFB operational approval in Advisory Circular (AC) 120.76D. The AC is intended for use by air carriers such as airlines and air charter companies. The primary purpose of this document is to assist air carriers in securing operational approval to use EFBs for specific functions. The document outlines limitations as they relate to performance calculations

accomplished by an EFB. Performance calculation software types are categorized by AC 120-76D. Type B software essentially replaces a paper AFM performance chart and requires specific authorization by the FAA prior to being used for performance determinations for an air carrier operation. This software essentially duplicates the manufacturer's performance information from the respective FAA-approved AFM by using the same input data with algorithms (FAA, 2017).

According to AC 120.76D, operational approval requires type B performance software to (1) adhere to existing approved data and be validated for accuracy within the entire aircraft operating envelope, (2) interpolate data, but not extrapolate data, and (3) be based upon existing published data found in the FAA-approved AFM, POH, or performance manual for an aircraft (FAA, 2017). The document also states that "applications are suitable only insofar as they accurately reproduce the AFM data" (FAA, 2017, p. 17). In the United States, air carriers, operators must go through at least a six-month demonstration period using EFBs to receive operational approval for (FAA, 2017).

An aviation software developer named Gyronimo has released several versions of their Performance Pad application. Unique versions of the Performance Pad are available for several small aircraft, many of which are used primarily for flight training. Gyronimo offers five types of performance planning for the Diamond DA 40, including weight and balance, takeoff, climb, cruise and landing performance. In many cases, the application provides more information than the AFM charts, essentially adding E6B flight planning capabilities. For this study, only the takeoff and landing performance data that could be verified with AFM charts was evaluated. Any additional information provided by Gyronimo would need to be investigated separately for validation.

When the Gyronimo Performance Pad application is first opened, it states "Please note: The Gyronimo Performance Pad is a student, professional pilot, and flight instructor assistance tool for plausibility checks and flight training only. All graphics and data provided in this application are used as examples. For flight planning, the original Pilot's Operating Handbook must be used!" (Gyronimo, 2017). However, if the Gyronimo application generates acceptable data, then it could potentially be approved and used in a flight training environment.

When using a computer to generate performance data, errors can occur. The human/software interface can have negative impacts upon accurate performance calculations. Data entry errors are the most common reason that software generates incorrect performance data (Australian Transport Safety Bureau, 2011). By design, the software should manage incorrect and/or inaccurate data entry. A recent study

investigated these types of errors and found that the primary human/machine interface concerns were data entry, reading, and selection errors (Joslin, 2013). If a pilot provides the software with incorrect input, the output will be incorrect. Not only does the software require correct input, but the assumptions made by the software must also reflect the data provided by the manufacturer (Bos, 2009).

Using a computer to determine performance parameters may simplify and shorten the process, but even professional pilots have made data entry errors, and these errors have caused accidents. In 2014, the Australian Transport Safety Bureau released a research report documenting how erroneous pilot input can cause performance planning errors which directly affected aviation safety. Their research investigated 31 international accidents and incidents in which data entry errors were a factor (ATSB, 2014). Each of these cases involved air carriers with experienced and trained flight crews. Despite all the training and certification requirements for both flight crews and EFB software, the human/machine interface and data entry errors are a major concern in aviation safety.

FAA Order 8900.1 provides many details for the evaluation of the software from a human factors perspective. The document includes a checklist to evaluate data entry issues. Specifically, the document addresses incorrect data entry and software behavior when the data entered is out of the operating envelope. For example, if a maximum gross takeoff weight is 2,646 pounds, but a user inputs 2,800 pounds, the software should recognize the incorrect data and generate an error message. Other suggested evaluation questions applicable to the software are included in Table 1.

Method

Takeoff and landing distances were calculated using AFM paper charts and then the Gyronimo application. The paper performance charts were retrieved from a Diamond DA40 Approved Airplane Flight Manual, Revision 8 (Diamond 2010). Twenty-five takeoff performance calculations and 24 landing performance calculations were generated based upon FAA and EASA guidance, effectively duplicating the typical EFB approval process for an air carrier. For each performance determination, all potential variables were manipulated to ensure a thorough evaluation. The first tests for takeoff and landing distances used the default variables described in the AFM. Subsequent tests then changed individual variables from their minimum to maximum value, and all other variables were consistent from the first test. Table 2 displays the specific test conditions for takeoff and landing distance. The landing distance with a tailwind was not included, as the AFM did not provide that data.

Table 1

FAA Order 8900.1: Checklist Items for Performance Calculations from the Electronic Flight Bag Program Evaluation and Authorization (FAA, 2017)

Question Number	Human/Machine Interface Questions
1	Does the device identify entries having an incorrect format or type and does it generate an appropriate error message?
2	Does the error message clarify the type and range of data expected?
3	Are units for performance data clearly labeled?
4	Do the labels used in the EFB match the language of the operator document?
5	Is all the information for a given task presented together or easily accessible?
6	Can the crews modify performance calculations easily, especially when making last-minute changes?
7	Are outdated results of performance calculations deleted when modifications are entered?
8	Does the display and/or crew training provide information to the crew on the assumptions on which the calculations are based?
9	Are the assumptions made about any calculation as clear to pilots as similar information would be on a tabular chart?

The European Aviation Safety Agency (EASA) is the civilian aviation authority for all European Union nations plus Switzerland, Norway, Iceland, and Liechtenstein (EASA, n.d.). In response to the growing number of applications for EFB approval, EASA performed research on how to improve the EFB operational approval process by surveying eleven different aviation authorities. Their findings recommend specific test points for performance scenarios, and each was used for the takeoff and landing performance calculations in this study. The recommended test points were as follows: (1) hot and high test condition, (2) standard atmosphere test condition, and (3) adverse weather/low-temperature condition (EASA, 2017). The report from EASA also recommended gathering data from other operator-specific test conditions.

Table 2
Specific Test Conditions

Test #	Specific Condition
1 AFM	All AFM Default
2 AFM	Max Gross Weight
3 AFM	Maximum tailwind (10 Knots)
4 AFM	Maximum Pressure Altitude
5 AFM	Maximum Outside Air Temperature
6 AFM	2 % Positive Runway Slope
7 AFM	Wet Grass (2-4 inches)
8 AFM	Hot, High (Pressure Altitude 9,000 feet and 30 C)
9 AFM	ISA Condition (MSL) with no Wind
10 AFM	ISA Condition (MSL) with 20 knot Headwind
11 AFM	ISA Condition (5,000 feet) with no Wind
12 AFM	ISA Condition (5,000 feet) with 20 Knot Headwind
13 AFM	Extreme Low Temperature (Pressure Altitude 1,000)
14 AFM	Temperature - 5 C
15 AFM	Temperature 15 C
16 AFM	Temperature 30 C
17 AFM	Pressure Altitude 1,000 feet
18 AFM	Pressure Altitude 4,000 feet
19 AFM	Pressure Altitude 8,000 feet
20 AFM	Weight 2,000 Pounds
21 AFM	Weight 2,400 Pounds
22 AFM	Weight 2,600 Pounds
23 AFM	7 Knot Headwind
24 AFM	14 Knot Headwind
25 AFM	20 Knot Headwind

First, takeoff and landing distances were generated using AFM charts. These charts provide example data for users. Both the takeoff and landing charts include the following four variables: outside air temperature (OAT), pressure altitude, airplane weight, and headwind component. These charts generate two distances for takeoff and landing. The ground roll is the distance the airplane travels on the runway, and the distances over a 50-foot obstacle provide the lateral distance required to either (1) climb to 50 feet AGL during takeoff or (2) descend and land from 50 feet AGL during landing. Examples of the AFM charts are provided in Figures 2 and 3.

The same data was then provided to the Gyronimo software for performance calculations. The software has two pages available for both takeoff and landing. The first page is the default page and displays all applicable variables and visually shows the ground roll and distance over a 50-foot obstacle. On the right side of the default page, the application provides specific takeoff data (accurate to the nearest whole foot). The application also allows for users to view the original AFM chart and shows (with circles) how each variable is placed into the calculation. These application pages are shown in Figures 4 and 5.

One challenge when comparing the distances generated by the two different methods was associated with the numbers themselves. The AFM charts are inherently less accurate than the numbers generated by Gyronimo. The pilot must properly use and interpret the chart. The method used to generate distances with the paper charts included a line that was about 10 feet thick on the paper chart. For this study, each AFM distance calculation was rounded to the nearest unit of 10 (i.e. 930 feet). An example of the AFM chart determination is shown in Figure 6. However, the distances generated by the Gyronimo application show the distance to the nearest foot (i.e., 943 feet).

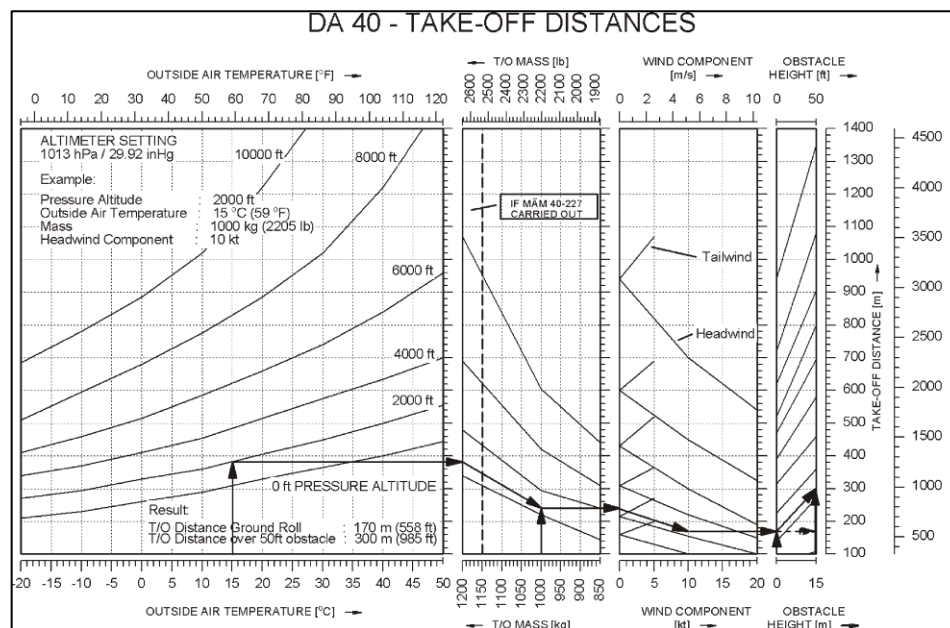


Figure 2. Default Conditions Provided on DA40 AFM Takeoff Distance Chart.

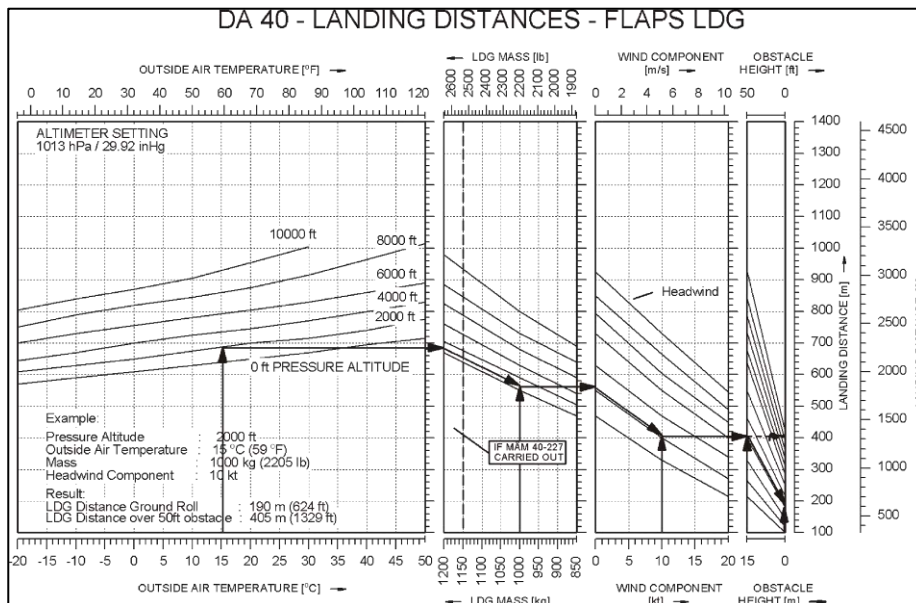


Figure 3. Default Conditions Provided on DA40 AFM Landing Distance Chart.

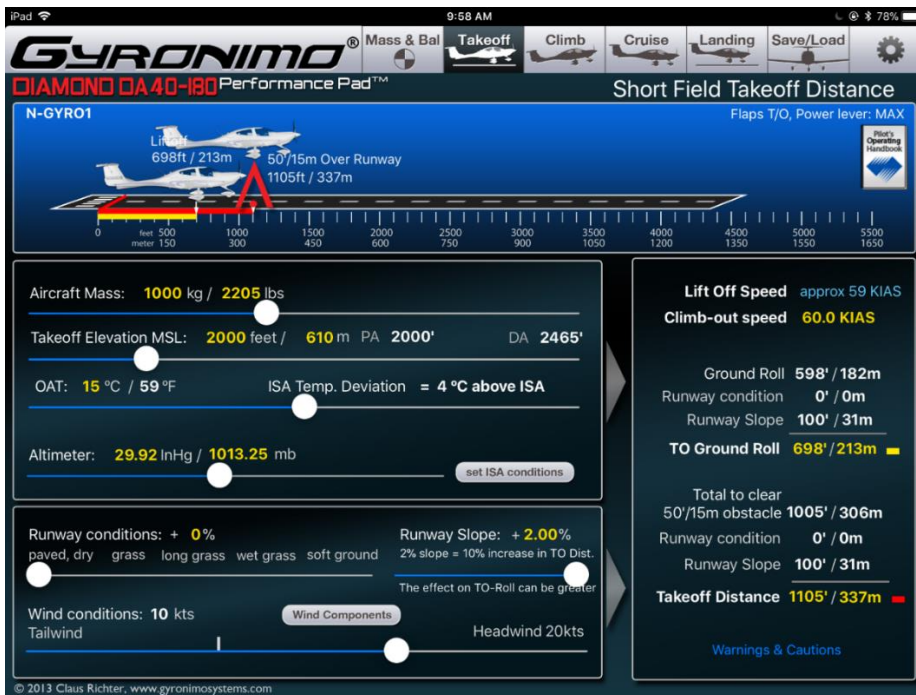


Figure 4. Gyronimo Performance Pad Takeoff Distance Default Page

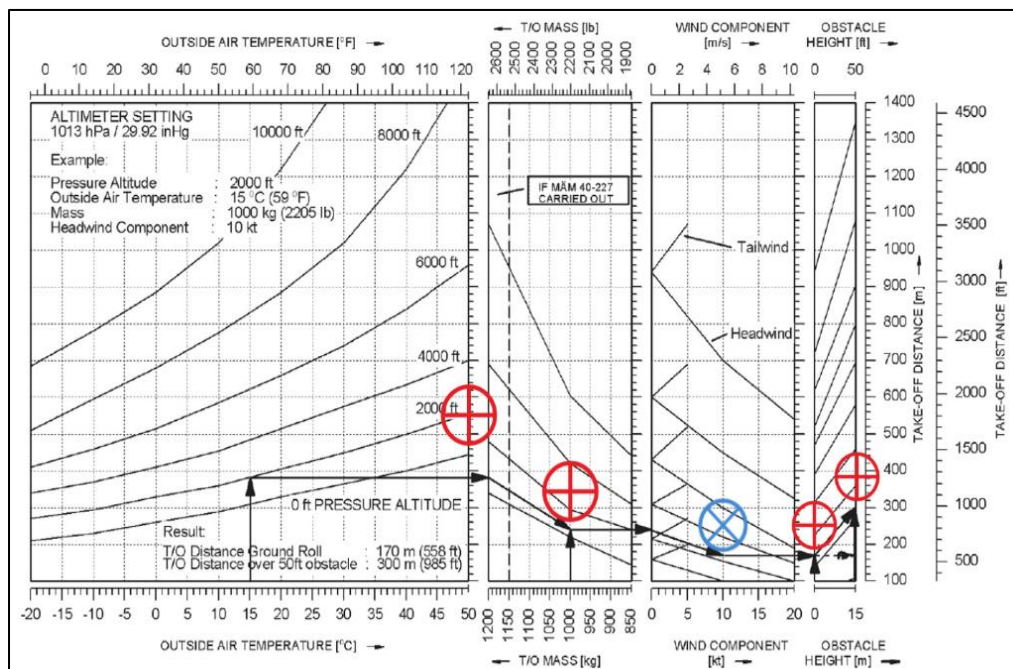


Figure 5. Gyronimo Performance Pad Takeoff Distance AFM Page.

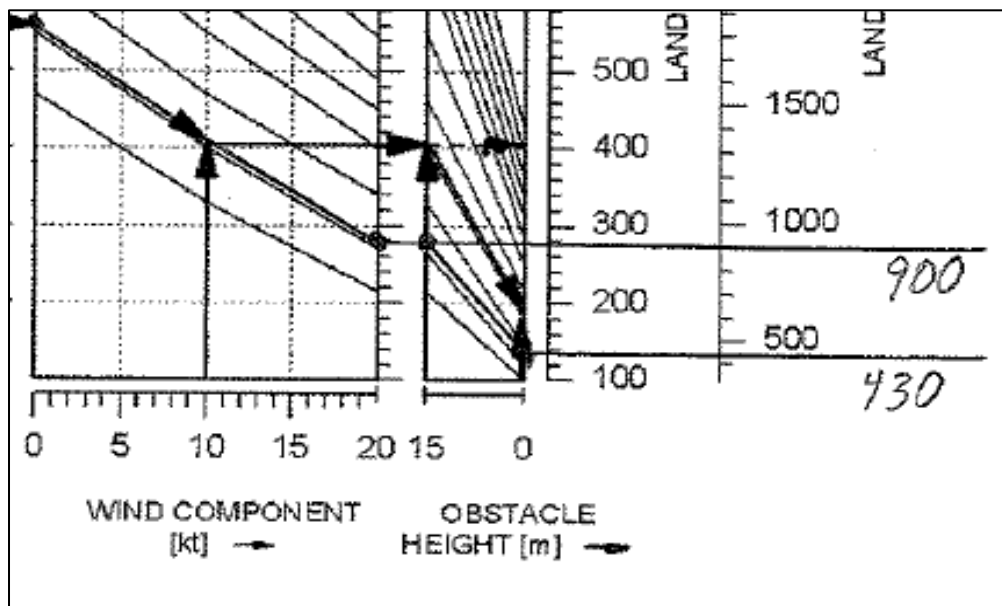


Figure 6. AFM Landing Distance Excerpt Showing Human Interpretation of Landing Ground Roll Distance and Landing Distance Over a 50-Foot Obstacle.

Results

In general, the Gyronimo application provided similar performance data as the AFM. The human/software interface had a few deviations from suggested behavior, but otherwise satisfied FAA recommendations. More importantly, the actual distances generated by Gyronimo were similar to data generated from the AFM. This results section first discusses the human/software interface issues and then provides the evaluation of the performance data generated by Gyronimo.

FAA guidance emphasizes that Type B performance applications may interpolate data, but must not extrapolate data. Prior to beginning calculations, the limits of takeoff and landing variables were compared. With some variables, the limits did not match. For example, the minimum and maximum pressure altitudes were slightly different. When calculating takeoff distance, the AFM charts allowed for a maximum tailwind of 20 knots, while the Gyronimo application had a tailwind limit of 10 knots. For landing calculations, the AFM charts provided no data for tailwinds, while the Gyronimo application allowed for up to 10 knots of tailwind. In this case, the application extrapolates data, which conflicts with FAA guidance. Tables 3 and 4 summarize the limits of specific variables for takeoff and landing performance when using both methods.

The human/software analysis of the Gyronimo software revealed that when data was entered incorrectly, the software did not generate a warning, and in many cases defaulted to a specific value. For example, when determining takeoff performance, the available weight range should be between 1,874 and 2,646 pounds. If a pilot manually enters 10 pounds, the software defaults to the lowest possible weight (1,874 pounds). Conversely, if a pilot enters a weight above the airplane's maximum gross takeoff weight, the software defaults to the maximum gross takeoff weight. It is important to note that in the Gyronimo software, all these values can be entered with sliders, but manual entry is also an option. Manual entry of intentionally incorrect data was used for this study. This process could not be accomplished when entering a pressure altitude or headwind, as those values were automatically generated by the software after the pilot enters other data. Table 5 summarizes incorrect data entry responses for two takeoff and landing performance variables.

Additional user interface issues were investigated using the FAA's software checklist from FAA Order 8900.1. The Gyronimo software satisfied several FAA requirements for interface items from the checklist. The units for performance calculations were clearly labeled, pilots could easily modify the input quickly, previous calculations were deleted once new data was entered, and the information

was presented just as clearly as it would be on the paper AFM charts. In addition, the “notes” section of the AFM is easily accessible inside the software, which provides assumptions for output data. Most of the language of the AFM and Gyronimo matched. A summary of these items can be found in Table 6.

Table 3

Summary of Variable Limitations with AFM and Gyronimo Takeoff Distance Calculation

Variable	AFM Limits	Gyronimo Limits
OAT	-20° C to 50° C	-20° C to 50° C
Pressure Altitude	- 3,000 feet to 10,000 feet	- 1,080 feet to 10,920 feet
Airplane Weight	1,874 lbs to 2,646 lbs	1,874 lbs to 2,646 lbs
Headwind	20 knot maximum	20 knot maximum
Tailwind	20 knot maximum	10 knot maximum
Obstacle height	0 feet to 50 feet	0 feet OR 50 feet
Runway Gradient/Slope %	Positive (no limit)	Up to + 2%

Table 4

Summary of Variable Limitations with AFM and Gyronimo Landing Distance Calculation

Variable	AFM Limits	Gyronimo Limits
OAT	-20° C to 50° C	-20° C to 50° C
Pressure Altitude	- 2,000 feet to 10,000 feet	- 1,080 feet to 10,920 feet
Airplane Weight	1,874 lbs to 2,646 lbs	1,874 lbs to 2,646 lbs
Headwind	20 knot maximum	20 knot maximum
Tailwind	No data	10 knot maximum
Obstacle height	0 feet to 50 feet	0 feet OR 50 feet
Runway Slope %	Negative (no limit)	Up to -2%

Table 5

Software Responses to Incorrect Data Entry

Variable	Data value too low	Data value too high	Incorrectly formatted data (i.e. letters)	Did software generate error message?
Temperature	Defaults to negative limit	Defaults to positive limit	Defaults to 0 degrees C	No
Weight	Defaults to negative limit	Defaults to positive limit	Defaults to negative limit	No

Table 6
Summary of FAA Order 8900.1 EFB Software Checklist Items

Question Number	Human/Machine Interface Questions	Gyronimo Behavior/Response
1	Does the device identify entries having an incorrect format or type and does it generate an appropriate error message?	No, the software defaults to largest or smallest possible value. There is no error message generated
2	Does the error message clarify the type and range of data expected?	N/A
3	Are units for performance data clearly labeled?	Yes
4	Do the labels used in the EFB match the language of the operator document?	Yes
5	Is all the information for a given task presented together or easily accessible?	Yes
6	Can the crews modify performance calculations easily, especially when	Yes
7	Are outdated results of performance calculations deleted when	Yes
8	Does the display and/or crew training provide information to the crew on the assumptions on which the calculations are based?	Yes
9	Are the assumptions made about any calculation as clear to pilots as similar information would be on a tabular chart?	Yes

The AFM notes for takeoff distance adjustments if the takeoff is from a grass runway are displayed in Figure 7. The AFM indicates that the takeoff roll will increase by certain percentages based upon the length of the grass. In addition, the note states that on wet grass, an additional 10% increase should be included in the takeoff roll. As for Gyronimo, the software has a slider bar which increases both the ground roll and takeoff distance progressively from a paved and dry runway, to grass, to long grass, then wet grass, and finally “soft ground.” These adjustments are displayed in Figure 8.

NOTE

For take-off from dry, short-cut grass covered runways, the following corrections must be taken into account, compared to paved runways (typical values, see CAUTION above):

- Grass up to 5 cm (2 in) long: 10 % increase in take-off roll.
- Grass 5 to 10 cm (2 to 4 in) long: 15 % increase in take-off roll.
- Grass longer than 10 cm (4 in): at least 25 % increase in take-off roll.
- Grass longer than 25 cm (10 in): take-off should not be attempted.

NOTE

On wet grass, a further 10 % increase in take-off roll must be expected.

Figure 7. AFM Notes on takeoff distance for grass runways.

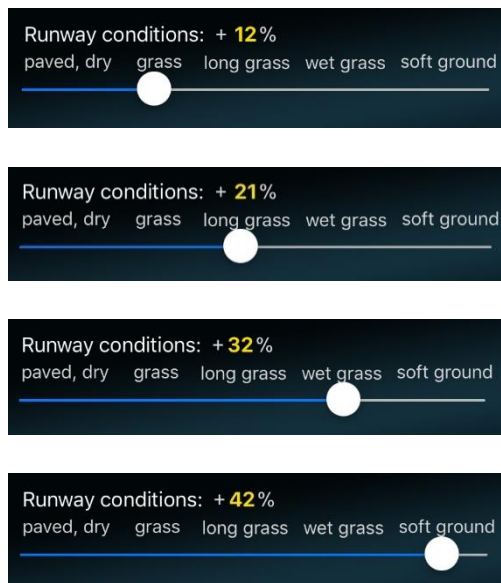


Figure 8. Gyronimo Adjustments on takeoff distance for grass runways.

The takeoff and landing distances generated for grass runways generated similar discrepancies. The AFM once again provides an increase in the landing roll based upon the height of the grass and then adds 10% more distance for wet grass. The Gyronimo landing page allows for a paved/dry runway, grass, long grass, and then finally long/wet grass. As the slider progresses through these conditions, only the ground roll is changed. Figures 9 and 10 display the landing distance adjustments for grass runways.

NOTE

For landings on dry, short-cut grass covered runways, the following corrections must be taken into account, compared to paved runways (typical values, see CAUTION above):

- Grass up to 5 cm (2 in) long: 5 % increase in landing roll.
- Grass 5 to 10 cm (2 to 4 in) long: 15 % increase in landing roll.
- Grass longer than 10 cm (4 in): at least 25 % increase in landing roll.

NOTE

On wet grass, a further 10 % increase in landing roll must be expected.

Figure 9. AFM Notes on landing distance for grass runways.

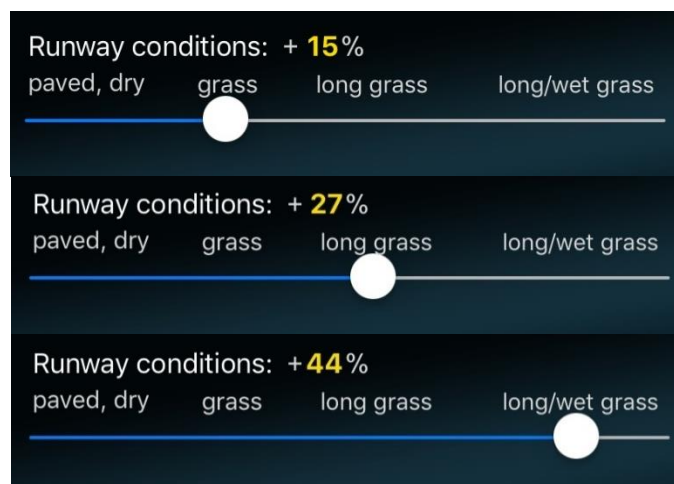


Figure 10. Gyronimo Adjustments on Landing Distance for Grass Runways.

Results indicated that the Gyronimo software provides accurate data when compared to the AFM charts. The takeoff performance comparison included 25 calculations, and the average variance between the AFM and Gyronimo distances were +/- 54 feet for ground roll, and +/- 56 feet for the takeoff distance over a 50-foot obstacle. The average ground roll was 752 feet and the average takeoff distance over a 50-foot obstacle was 1,210 feet. The landing performance comparison included 24 calculations, and the average variance between the AFM and Gyronimo distances were +/- 54 feet for ground roll, and +/- 76 feet for the landing distance over a 50-foot obstacle. The average landing ground roll was 688 feet, and the average landing distance over a 50-foot obstacle was 1,466 feet. The takeoff and landing performance data is summarized in Tables 7 and 8.

Table 7
Takeoff Distance Calculations and Variances

Test #	Specific Condition	Ground Roll (ft)	Distance over 50-Foot Obstacle (ft)	Ground Roll Variance	50-ft Obstacle Variance
1 AFM	All AFM Default	558	985	40	20
1 GYR		598	1,005		
2 AFM	Max Gross Weight	850	1,260	58	93
2 GYR		908	1,353		
3 AFM	Maximum Tailwind (10 Knots)	1,110	1,610	73	107
3 GYR		1,183	1,717		
4 AFM	10,000 Feet Pressure Altitude	1,710	2,500	186	289
4 GYR		1,524	2,211		
5 AFM	Maximum Outside Air Temperature (50 C)	820	1,300	1	47
5 GYR		819	1,253		
6 AFM	2 % Positive Runway Slope	613	1,083	85	22
6 GYR		698	1,105		
7 AFM	Wet Grass (2-4 inches)	698	1,125	211	191
7 GYR		909	1,316		
8 AFM	Hot, High (Pressure Altitude 9,000 feet and 30 C)	1,870	2,710	116	165
8 GYR		1,754	2,545		
9 AFM	ISA Condition (MSL) with no Wind	640	1,090	48	16
9 GYR		688	1,106		
10 AFM	ISA Condition (MSL) with 20 knot Headwind	290	710	37	1
10 GYR		327	709		
11 AFM	ISA Condition (5,000 feet) with no Wind	1,010	1,440	13	14
11 GYR		997	1,454		
12 AFM	ISA Condition (5,000 feet) with 20 Knot Headwind	420	890	47	34
12 GYR		467	856		

Table 7 Continued

Test #	Specific Condition	Ground Roll (ft)	Distance over 50-Foot Obstacle (ft)	Ground Roll Variance	50-ft Obstacle Variance
13 AFM	Extreme Low Temperature (Pressure Altitude 1,000)	300	720	59	6
13 GYR		359	726		
14 AFM	Temperature - 5 C	490	910	22	2
14 GYR		512	908		
15 AFM	Temperature 15 C	558	985	40	20
15 GYR		598	1,005		
16 AFM	Temperature 30 C	600	1,040	79	56
16 GYR		679	1,096		
17 AFM	Pressure Altitude 1,000 feet	520	1,000	33	46
17 GYR		553	954		
18 AFM	Pressure Altitude 4,000 feet	690	1,120	32	24
18 GYR		722	1,144		
19 AFM	Pressure Altitude 8,000 feet	1,190	1,690	6	45
19 GYR		1,196	1,735		
20 AFM	Weight 2,000 Pounds	440	890	46	12
20 GYR		486	878		
21 AFM	Weight 2,400 Pounds	700	1,100	39	64
21 GYR		739	1,164		
22 AFM	Weight 2,600 Pounds	870	1,310	7	8
22 GYR		877	1,318		
23 AFM	7 Knot Headwind	610	1,010	52	67
23 GYR		662	1,077		
24 AFM	14 Knot Headwind	490	920	22	12
24 GYR		512	908		
25 AFM	20 Knot Headwind	390	790	6	34
25 GYR		384	756		

Table 8
Landing Distance Calculations and Variances

Test #	Specific Condition	Ground Roll (ft)	Distance over 50 foot obstacle (ft)	Ground Roll Variance	50-ft Obstacle Variance
1 AFM	All AFM Default	624	1,329	27	72
GYR		651	1,401		
2 AFM	Max Gross Weight	710	1,690	157	149
GYR		867	1,839		
3 AFM	10,000 Feet Pressure Altitude	870	1,900	73	84
GYR		943	1,984		
4 AFM	OAT 50 Degrees C	790	1,580	27	44
GYR		763	1,624		
5 AFM	Hot, High (Pressure Altitude 9,000 feet and 30 C)	880	1,910	95	138
GYR		975	2,048		
6 AFM	ISA (MSL) No Wind	790	1,730	22	8
GYR		812	1,722		
7 AFM	ISA (MSL) 20 knot Headwind	360	780	48	50
GYR		408	830		
8 AFM	ISA Condition (5,000 feet) with no Wind	900	2,000	65	28
GYR		965	2,028		
9 AFM	ISA Condition (5,000 feet) with 20 Knot Headwind	430	1,030	75	48
GYR		505	1,078		
10 AFM	Extreme Low Temperature (Pressure Altitude 1,000 feet)	490	1,090	59	88
GYR		549	1,178		
11 AFM	Temperature - 5 C	540	1,210	54	68
GYR		594	1,278		
12 AFM	Temperature 15 C	624	1,329	27	72
GYR		651	1,401		
13 AFM	Temperature 30 C	690	1,420	10	78
GYR		700	1,498		
14 AFM	Pressure Altitude 1,000 feet	590	1,280	29	56
GYR		619	1,336		
15 AFM	Pressure Altitude 4,000 feet	650	1,450	72	93
GYR		722	1,543		
16 AFM	Pressure Altitude 8,000 feet	740	1,700	122	122
GYR		862	1,822		
17 AFM	Weight 2,000 lbs	520	1,180	64	76
GYR		584	1,256		

Table 8 Continued

Test #	Specific Condition	Ground Roll (ft)	Distance over 50 foot obstacle	Ground Roll Variance	50-ft Obstacle Variance
18 AFM	Weight 2,400 lbs	730	1,490	2	73
GYR		732	1,563		
19 AFM	Weight 2,600 lbs	790	1,630	61	176
GYR		851	1,806		
20 AFM	7 Knot Headwind	710	1,520	12	22
GYR		722	1,542		
21 AFM	14 Knot Headwind	570	1,180	6	32
GYR		564	1,212		
22 AFM	20 Knot Headwind	430	900	14	29
GYR		444	929		
23 AFM	Wet Grass (2-4 inches)	780	1,485	158	202
GYR		938	1,687		
24 AFM	2% Negative Runway Slope	686	1,462	30	4
GYR		716	1,466		

Discussion

In this study, the Gyronimo Performance Pad application was evaluated as if it were a Type B EFB application proposed for performance calculations with an air carrier. The high standards set forth by the FAA and EASA in terms of software interface and calculation accuracy are required for air carriers, but this software was not developed with these standards in mind. However, the software did meet several interface standards and also generated reliable performance data.

The largest discrepancies in terms of the human/software interface were the lack of error messages when incorrect data was entered and the variable limitations. A major concern with the human/software interface was the potential of incorrect data entry. As previously discussed, the application does not generate error messages when data is entered that exceeds limitations or if the data is entered with an incorrect format. Instead, the software defaults to either the lowest or highest value. When the format of the data is incorrect (i.e., entering letters instead of numbers), the software then defaults to the lowest value. This is of concern, as data entry errors have been identified as the most common factor in EFB - related accidents (EASA, 2017).

For takeoff performance, the AFM data allows for up to 20 knots of tailwind, and the Gyronimo software only allows for tailwinds of up to 10 knots. In this case, the software does not extrapolate data, but it does not provide all the data provided by the AFM charts. Also, for landing distance, the AFM charts do not provide any data for landing with a tailwind, while the Gyronimo application allows for up to 10 knots of tailwind. In this case, the software is extrapolating data not provided by the AFM. These discrepancies in the allowance of performance variables should be noted by flight schools that plan to use the software, and perhaps policies could be generated to prohibit Gyronimo calculations when extrapolation is possible (i.e. tailwind for landing distance). These variable limitations were investigated as suggested by the FAA.

The performance calculations generated by the two methods were fairly consistent. The average variance between output never exceeded 76 feet, which reflects accuracy when measuring distances that average 688 feet and 1,466 feet, respectively. Although these average variations were noted, it was apparent that some conditions caused greater variance. For example, the “hot and high” test condition (as recommended by EASA) and “wet grass” condition generated larger than average variances for both the takeoff and landing distances generated by Gyronimo. These conditions typically do not occur during primary flight training, but this discrepancy is worth noting because the issue was found for both takeoff and landing distances with Gyronimo.

During the landing distance calculations, with all three pressure altitude tests, as pressure altitude increased, the variance between the AFM and Gyronimo calculations increased. This is the type of information that an air carrier or flight school would carefully test, and if these variances are found to be too great, then the use of the application may be limited based upon pressure altitude. Similar pressure altitude tests used for the takeoff distance calculation did not produce the same pattern.

Airplane Flight Manuals are constantly updated with revisions from the manufacturer, and sometimes these revisions make adjustments to performance charts. This is certainly the case with the Diamond DA40 AFM used in this research. Previously, it was specifically stated that the AFM used in this study was current through revision 9. Prior versions of the DA40 AFM did not provide the specific grass length data found in the current version of the document. For practical purposes, any operator planning to use a performance software must refer to a current AFM for comparisons.

Limitations

This study had several limitations. One specific software was tested against one specific AFM revision. Also, that application was developed for one aircraft type. Only two of the five available Gyronimo performance calculations were tested. The biggest potential limitation was the AFM data generated by the AFM charts and the increments in which the data was recorded (increments of 10 feet). The PI, while experienced with these paper charts, could have made errors when generating the AFM performance calculations. These results must not be extrapolated for other Gyronimo products on other aircraft, and are limited to the takeoff and landing performance data for a Diamond DA40.

Suggested Additional Research

Errors in performance calculations were briefly mentioned in the literature review, but this issue could create unsafe conditions and even lead to accidents. Incorrectly calculated takeoff and landing data can lead to tail strikes, the inability to take off, or similar complications upon landing. It is suggested that pilots perform these calculations using AFM and application data, and then to investigate potential data input errors when using both.

In an industry that is constantly introducing new forms of automation, this data may encourage flight schools to allow student pilots to use similar software for performance calculations. Flight schools, if interested in this technology, must also consider when to introduce it in the curriculum. Pilots could use it when training at the private, instrument or commercial level. This should be investigated to streamline training and better prepare pilots for industry. However, automation can reduce skills, and if performance calculations are also automated, a pilot may be able to use software to do calculations but may not fully understand performance factors. Software such as Gyronimo could be used to investigate potential negative outcomes of automating performance planning.

Conclusion

During primary flight training, pilots are increasingly using EFBs for aeronautical charts, checklists, weather information, and many other functions. If pilots in training can use EFB software to determine accurate performance data, then they could benefit from using such technology. The Gyronimo Performance Pad for the Diamond DA40 is a reliable source of takeoff and landing performance for typical conditions. If reviewed and implemented by a flight school, this application could provide flight instructors and students the opportunity to use a

software for essential performance planning during flight training. This may better prepare pilots in training because pilots in industry routinely perform performance calculations using EFBs. If flight schools are interested in using performance software such as Gyronimo, then the software should be tested with the current version of the specific aircraft AFMs.

For software developers such as Gyronimo, there may be a new market in which software such as this can be used on a large-scale basis at flight schools across the globe. These companies must be careful to accurately present this data, as it is directly related to flight safety. Gyronimo took such precaution when it warned users of the advisory nature of their software when the application is first opened. However, if the application meets the aviation authority's standards for air carriers, and is thoroughly tested and verified, then EFB software such as Gyronimo could be used for commercial operations and primary flight training.

References

- Aircraft Performance Group. (n.d.). *Building on a legacy of engineering experience and excellence*. Retrieved from <https://www.flyapg.com/history/>
- Australian Transport Safety Bureau (ATSB). (2011). *Take-off performance calculation and entry errors: A global perspective*. Retrieved from <https://www.atsb.gov.au/media/2229778/ar2009052.pdf>
- Trump, R.S., Van Es, G.W.H., Karwal, A.K., & Verbeek, M.J. (2014). Best practices for approval of performance and MB applications on EFBs. *Australian Transport Safety Bureau*. Retrieved from <https://www.easa.europa.eu/sites/default/files/dfu/EASA-Research-Rep-2014-1.pdf>
- Bos, T. (2009). Takeoff performance margins. *Dutch Airline Pilots Association*. Retrieved from <https://www.vnv.nl/publications/takeoff-performance-margins>
- Cassidy, E. D., Colmenares, A., Jones, G., Manolovitz, T., Shen, L., & Viera, S. (2014). Higher education and emerging technologies: Shifting trends in student usage. *The Journal of Academic Librarianship*, 40(2), 124-133
- Diamond Aircraft. (2010). *FAA approved airplane flight manual*. Retrieved from http://support.diamond-air.at/fileadmin/uploads/files/after_sales_support/DA40-180/Airplane_Flight_Manual/Basic_Manual/60101e-r9-complete.pdf
- European Aviation Safety Agency. (n.d.). *The agency: Facts and figures*. Retrieved from <https://www.easa.europa.eu/the-agency/the-agency>
- European Aviation Safety Agency, (2015). *Final report: Electronic flight bag; Aircraft performance calculations and mass & balance. Best practices for evaluation and use of EFB*. Retrieved from <https://www.easa.europa.eu/sites/default/files/dfu/EASA-Research-Rep-2014-1.pdf>
- Federal Aviation Administration. (2017). *Electronic flight bag program evaluation and authorization*. Retrieved from <http://fsims.faa.gov/wdocs/>

8900.1/v04%20ac%20equip%20&%20auth/chapter%2015/04_015_001_c
hg_260a.htm

Federal Aviation Administration. (2017). *Landing distance assessment at time of arrival*. Retrieved from <https://www.faa.gov/about/initiatives/talpa/media/order-8900-1-vol4-chap3-section1-par503-2017.pdf>

Federal Aviation Administration (2017). *Advisory Circular 120.76D: Authorization for use of electronic flight bags*. Retrieved from https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_120-76D.pdf

Federal Aviation Administration. (2018). *Electronic code of federal regulations 91.103: Preflight action*. Retrieved from https://www.ecfr.gov/cgi-bin/text-idx?SID=1ec519dc9ba983736d762befddd64aa1&mc=true&node=se14.2.91_1103&rgn=div8

Federal Aviation Administration. (2017). *Private pilot-airplane airman certification standards*. Retrieved from https://www.faa.gov/training_testing/testing/acs/media/private_airplane_acs_6A.pdf

ForeFlight Mobile. (n.d.). *ForeFlight performance profiles*. Retrieved from https://www.foreflight.com/products/performance/directory/#/Diamond%20Aircraft/?_k=zy3bpl

Joslin, R. (2013). Human factors hazards of iPads in general aviation cockpits. *Proceedings of the Human Factors and Ergonomics Society 57th Annual Meeting*.

Schwartzentruber, J. (2017). A usability study for electronic flight bag (EFB) flight planning applications on tablet devices for ab-initio pilots. *The International Journal of Aviation, Aeronautics, and Aerospace*, 4(2). doi:<https://doi.org/10.15394/ijaa.2017.1162>

Appendix A: Takeoff Performance Chart Comparisons

Takeoff Comparison 1: AFM Default Information

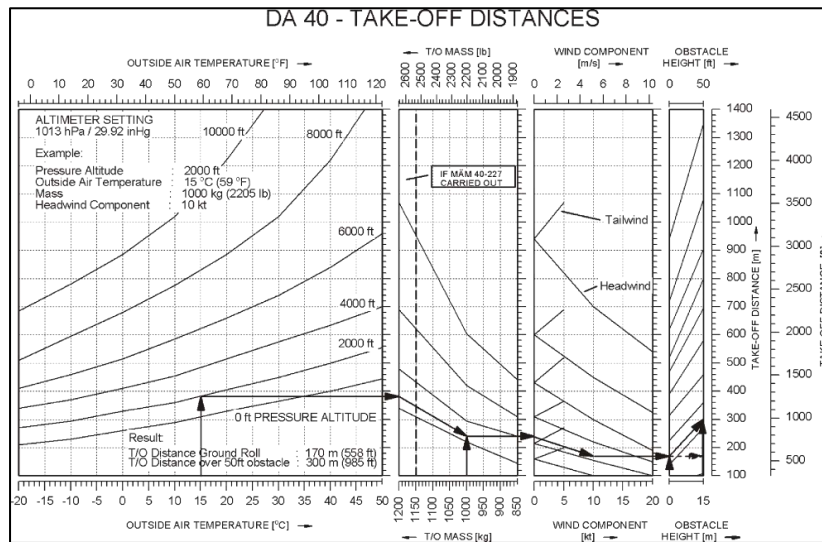


Figure 1. AFM Default Variables Takeoff Determination

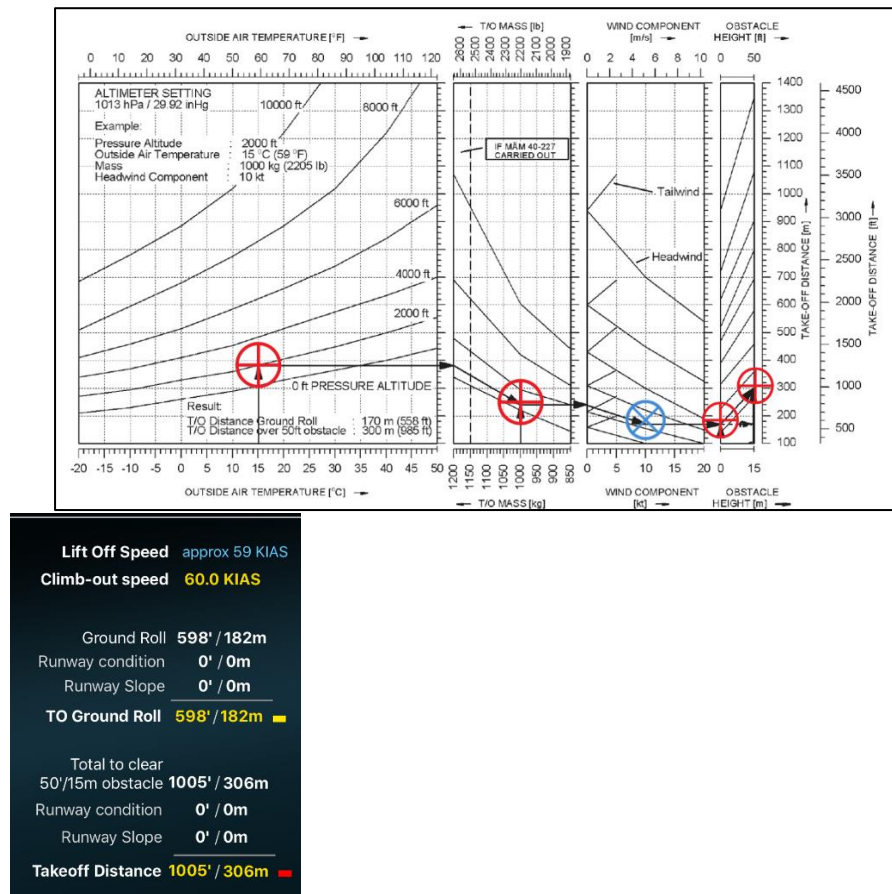


Figure 2. Gyronimo Default Variables Takeoff Determination

Takeoff Comparison 2: Maximum Gross Weight

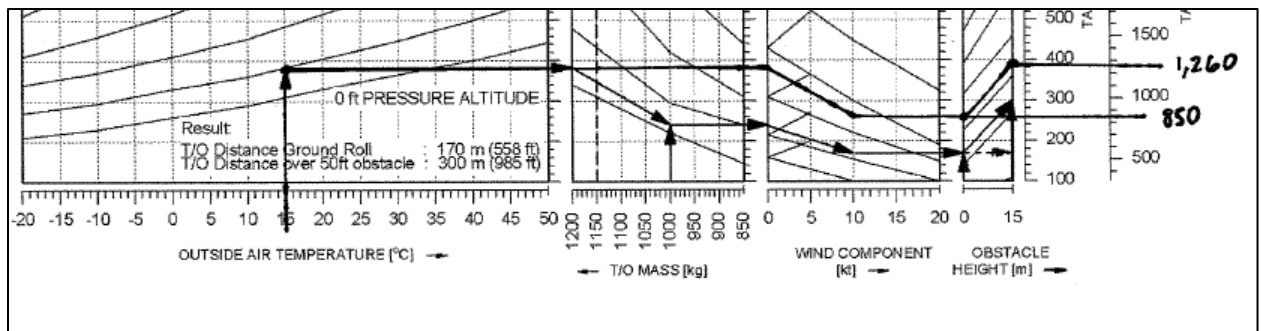


Figure 3. AFM Maximum Gross Weight with Default Variables Takeoff Determination

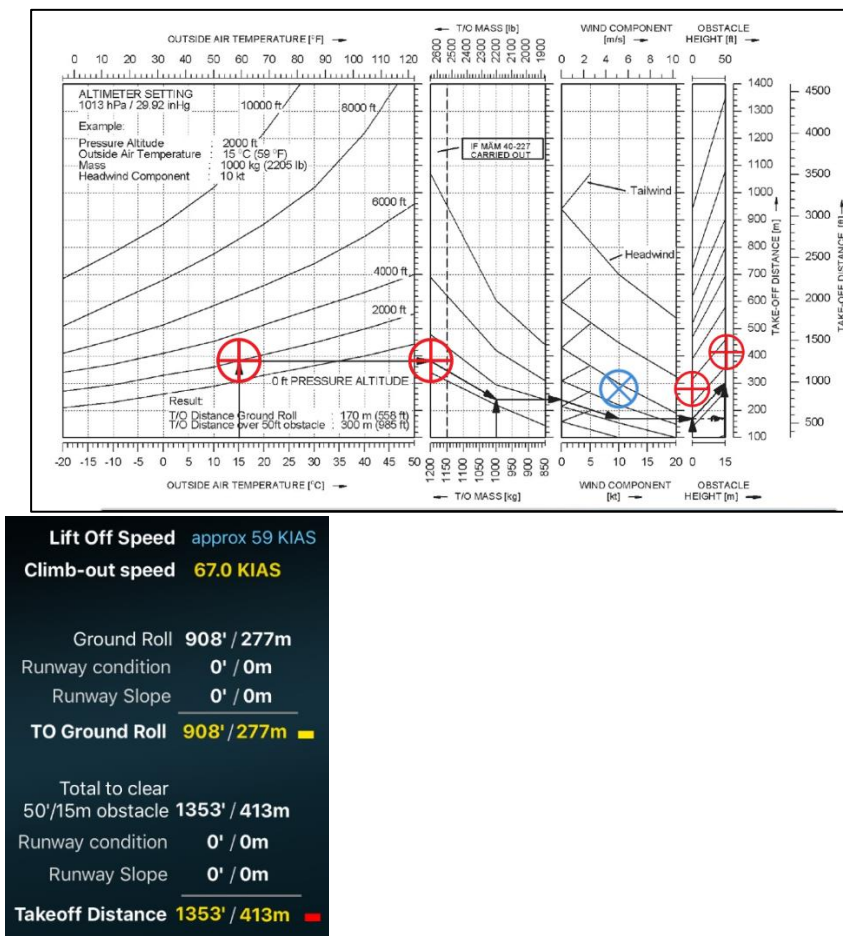


Figure 4. Gyronimo Maximum Gross Weight with Default Variables Takeoff Determination

Takeoff Comparison 3: Maximum Tailwind (10 knots)

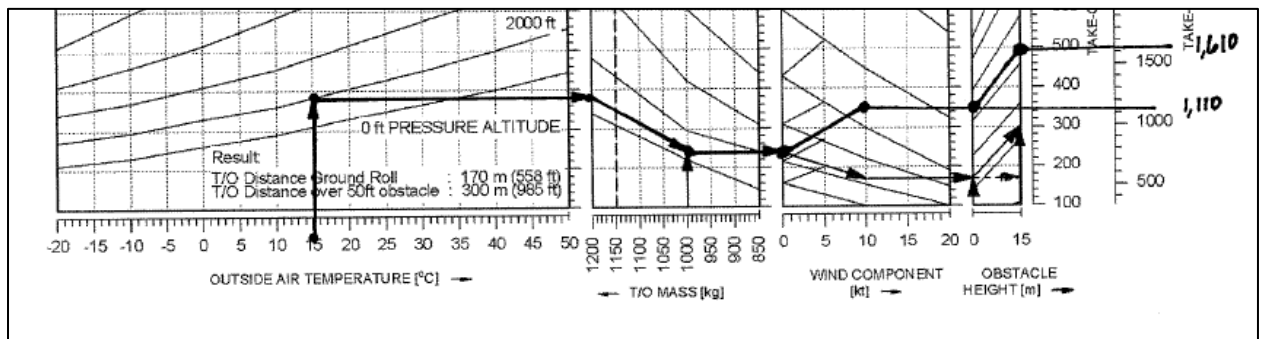


Figure 5. AFM Maximum Tailwind with Default Variables Takeoff Determination

Takeoff Comparison 4: Maximum Pressure Altitude (10,000 feet)

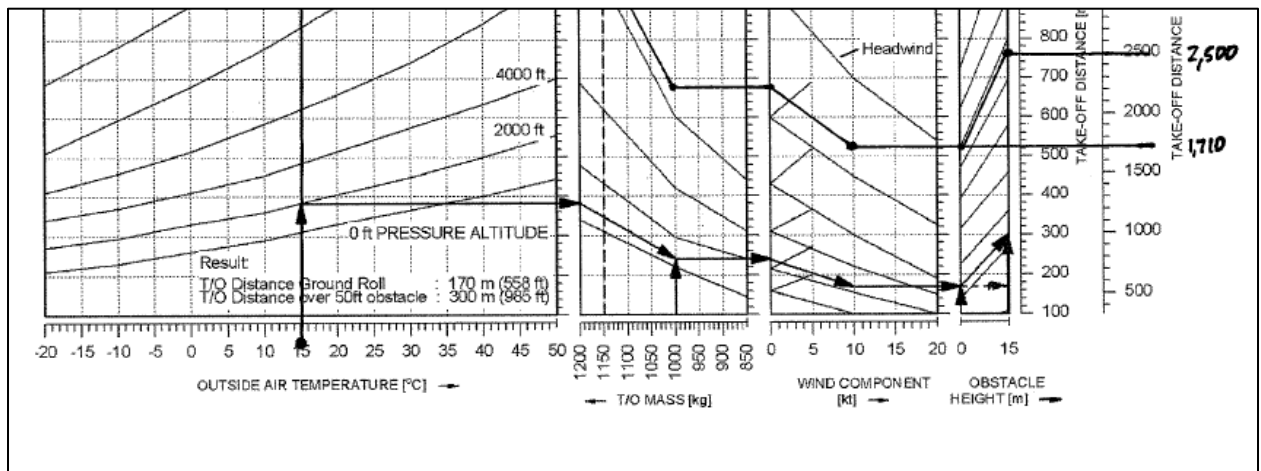


Figure 7. AFM Maximum Pressure Altitude with Default Variables Takeoff Determination

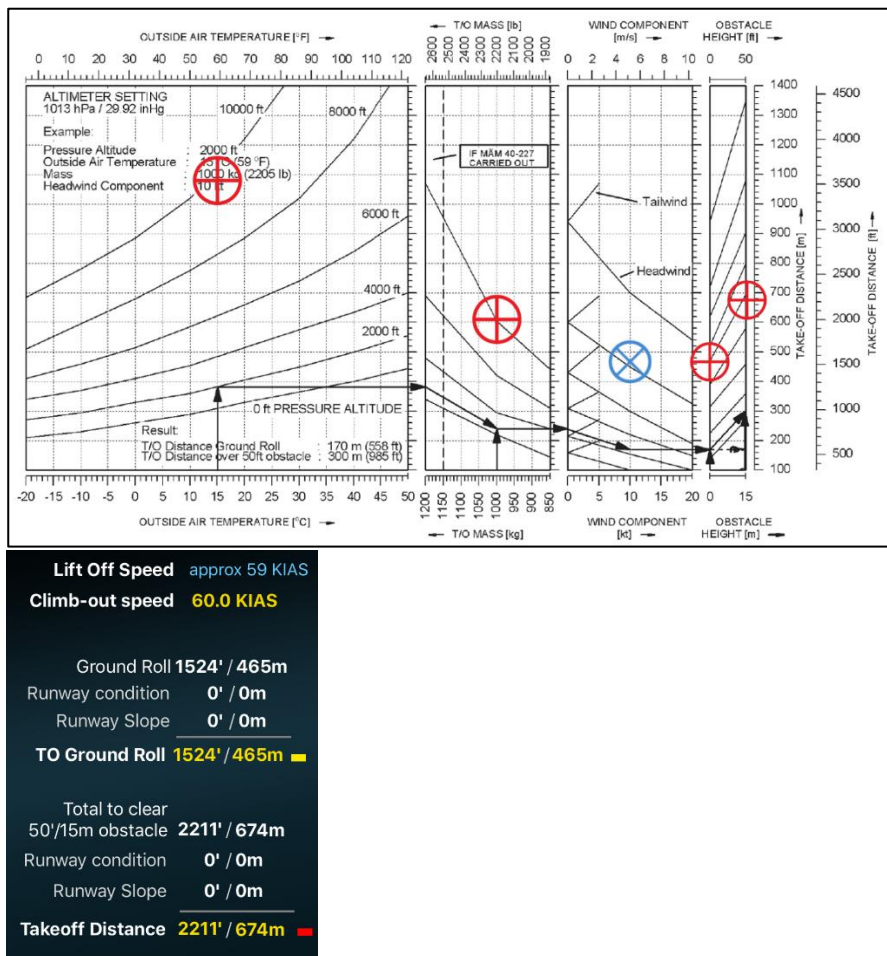


Figure 8. Gyronimo Maximum Pressure Altitude with Default Variables Takeoff Determination

Takeoff Comparison 5: Maximum Temperature (50C)

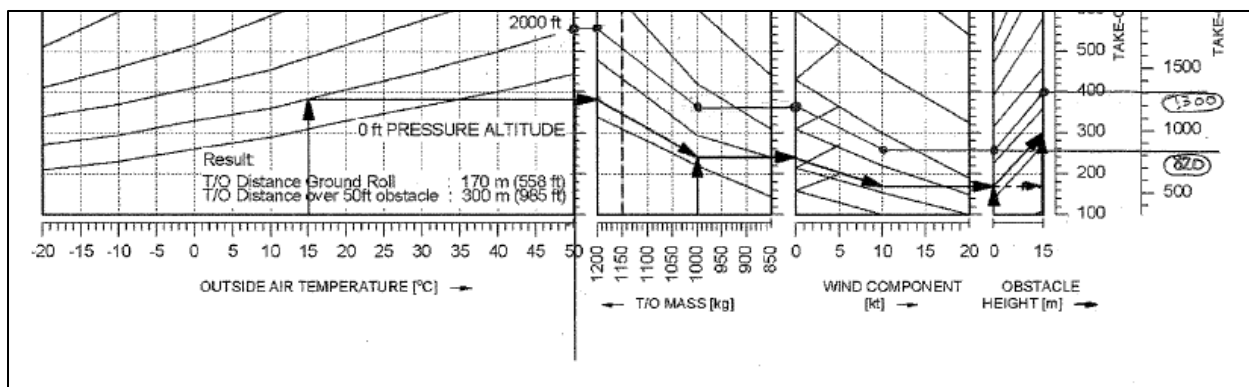
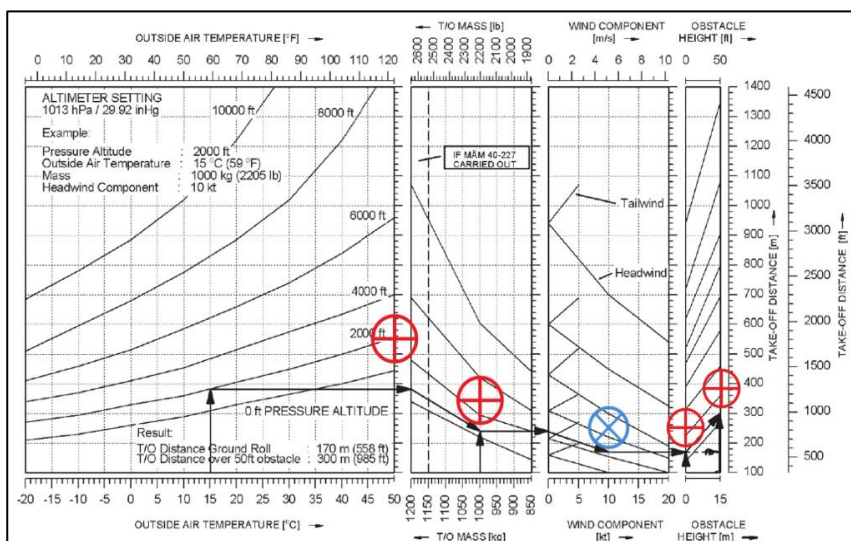


Figure 9. AFM Maximum Temperature with Default Variables Takeoff Determination



Altimeter Setting	1013 hPa / 29.92 inHg
Example:	
Pressure Altitude	2000 ft
Outside Air Temperature	15 °C (59 °F)
Mass	1000 kg (2205 lb)
Headwind Component	10 kt
Result:	
T/O Distance Ground Roll	170 m (558 ft)
T/O Distance over 50ft obstacle	300 m (985 ft)
Lift Off Speed	approx 59 KIAS
Climb-out speed	60.0 KIAS
Ground Roll	819' / 250m
Runway condition	0' / 0m
Runway Slope	0' / 0m
TO Ground Roll	819' / 250m
Total to clear 50'/15m obstacle	1253' / 382m
Runway condition	0' / 0m
Runway Slope	0' / 0m
Takeoff Distance	1253' / 382m

Figure 10. Gyronimo Maximum Temperature with Default Variables Takeoff Determination

Takeoff Comparison 6: 2% Positive Runway slope

With default conditions, the AFM yielded a Ground Roll of 558 feet and a distance over a 50 foot obstacle of 985 feet.

The AFM take off notes state that a 2% positive slope would increase the takeoff distance by approximately 10%. It did not provide for negative runway slope takeoff variables. Thus, with a positive 2% runway slope, the increase would be +10%, yielding a ground roll of 613 feet and a takeoff distance over a 50 foot obstacle of 1,083 feet.

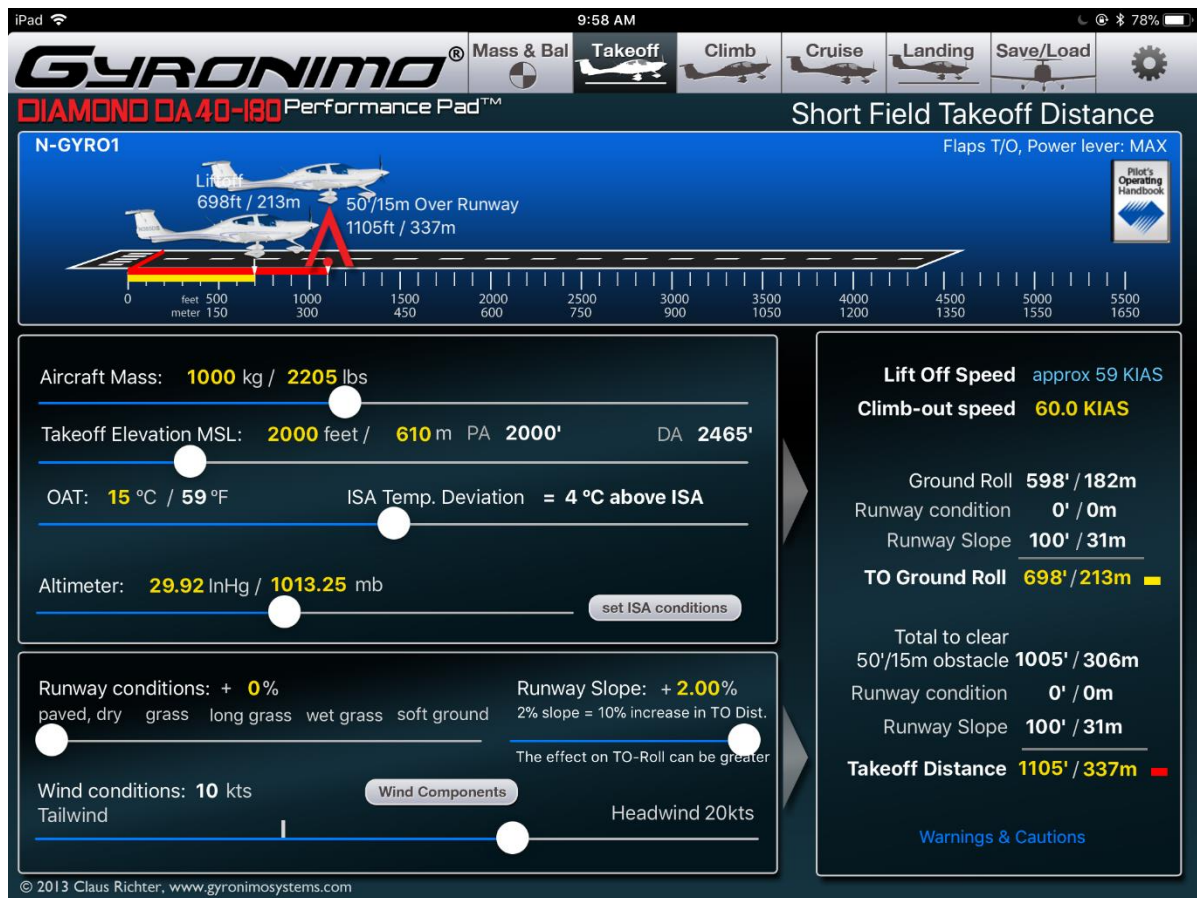


Figure 11. Gyronimo Takeoff Determination with + 2% Runway Slope

Takeoff Comparison 7: Default Variables on Wet Grass

With default conditions, the AFM yielded a Ground Roll of 558 feet and a distance over a 50 foot obstacle of 985 feet.

The AFM states that grass from two to four inches high will add 15% to the takeoff ground roll, and that wet grass would add an additional 10%. Thus, the

AFM produced a wet grass ground roll of 698 feet and a distance over a 50-foot obstacle of 1,125 feet.

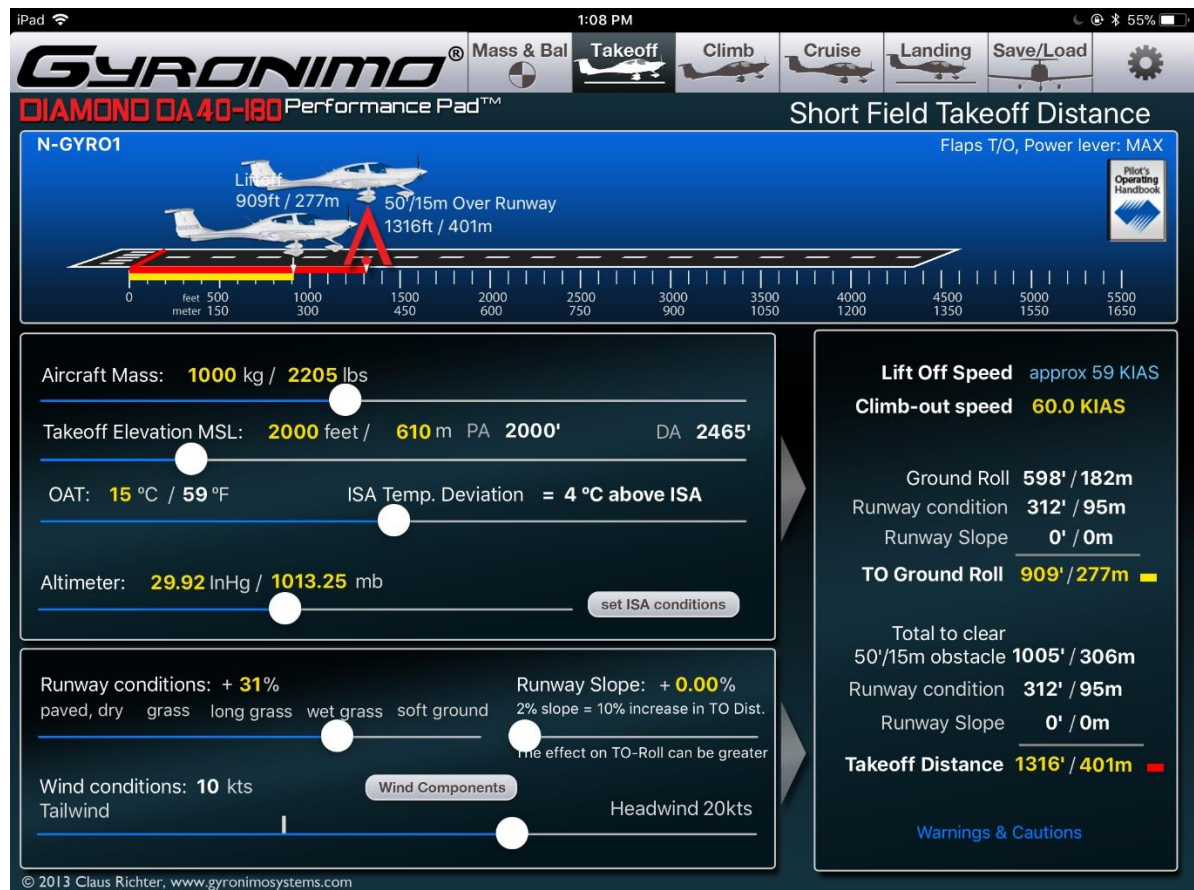


Figure 12. Gyronimo Default Takeoff Variables with Wet Grass

Takeoff Comparison 8: Hot and High Condition (EASA)

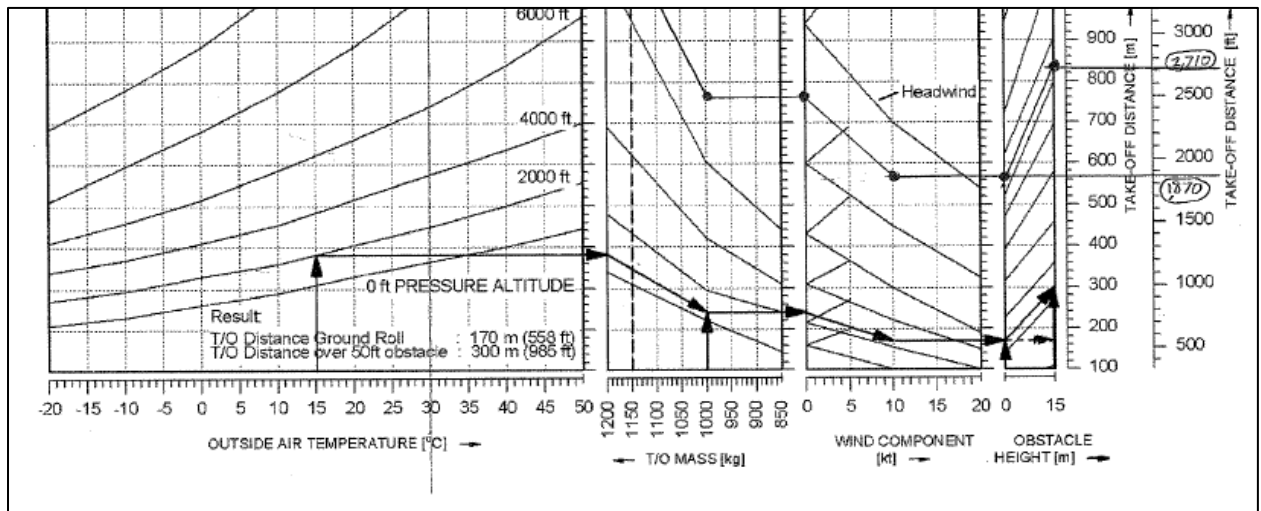


Figure 13. AFM Hot and High Takeoff Determination

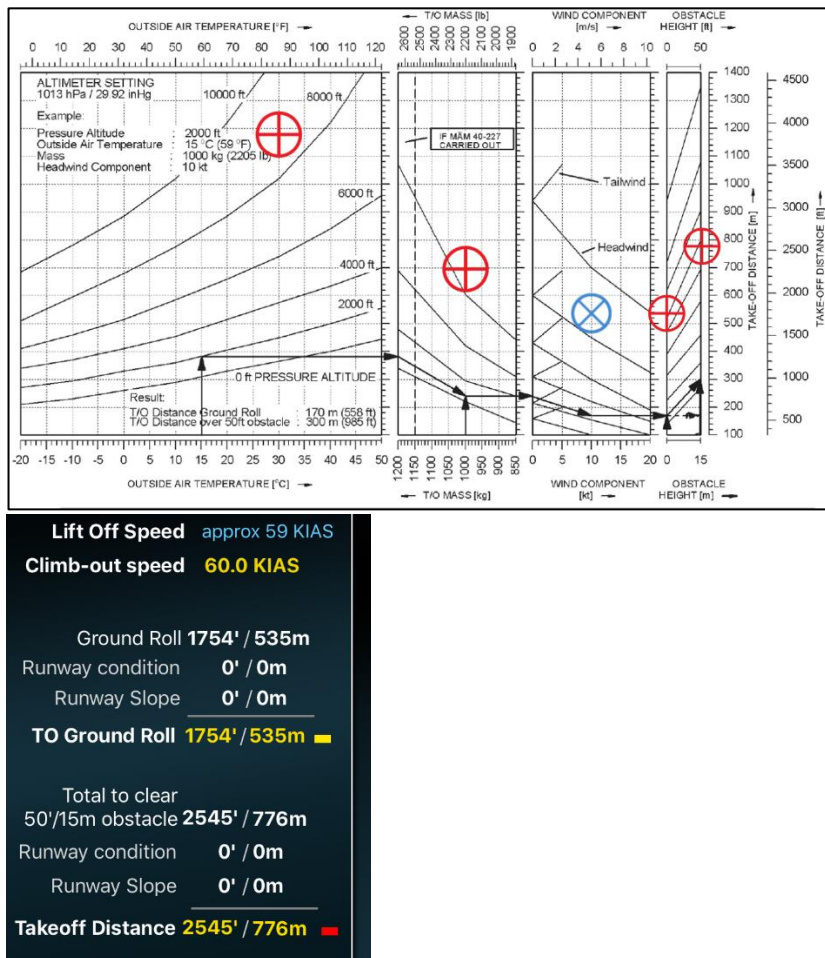


Figure 14. Gyronimo Hot and High Takeoff Determination

Takeoff Comparison 9: ISA at MSL with No Wind

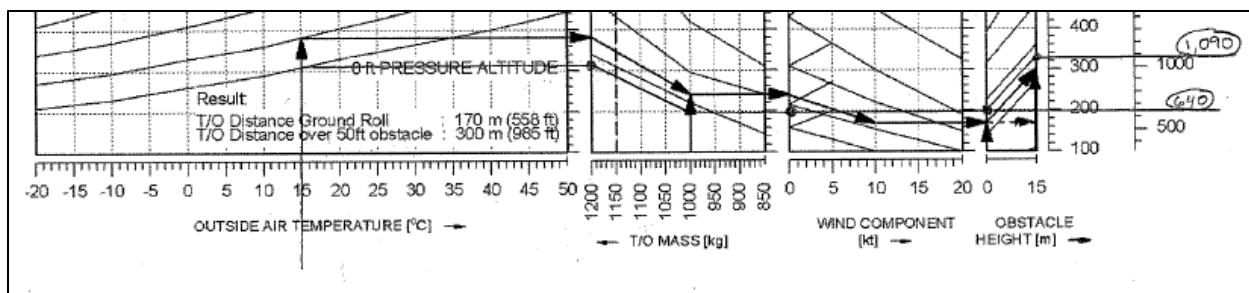


Figure 15. AFM ISA at MSL with No Wind Takeoff Determination

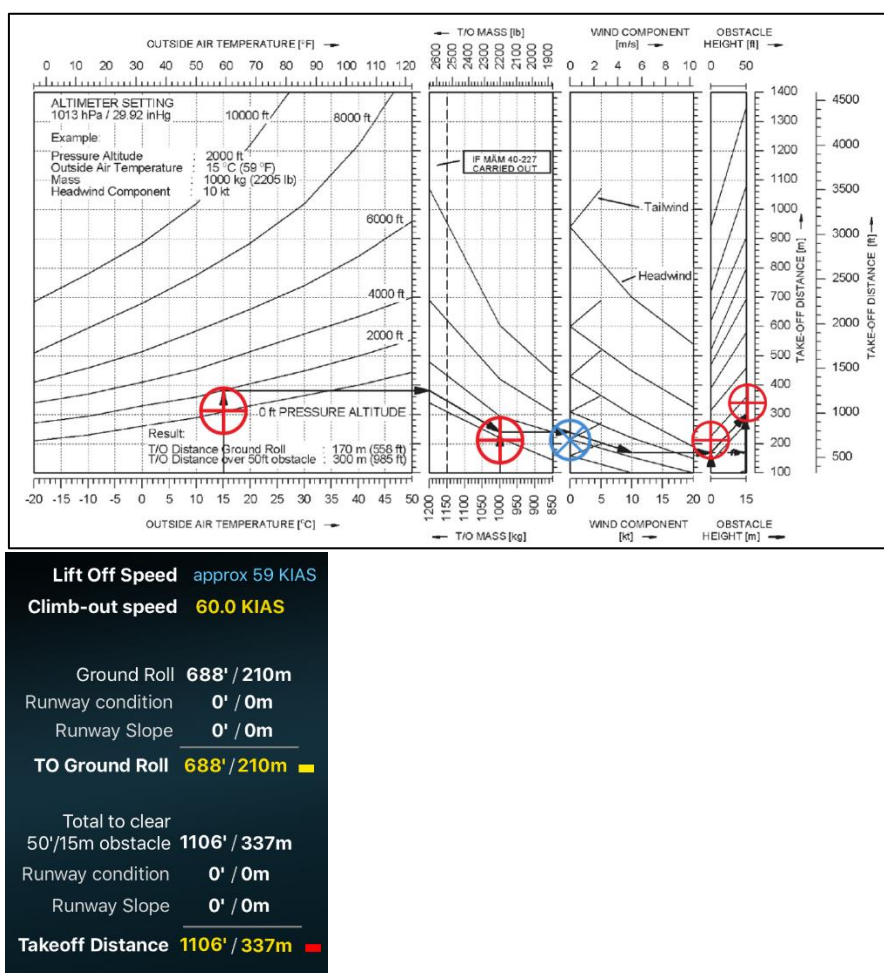


Figure 16. Gyronimo ISA at MSL with No Wind Takeoff Determination

Takeoff Comparison 10: ISA at MSL with 20 Knot Headwind

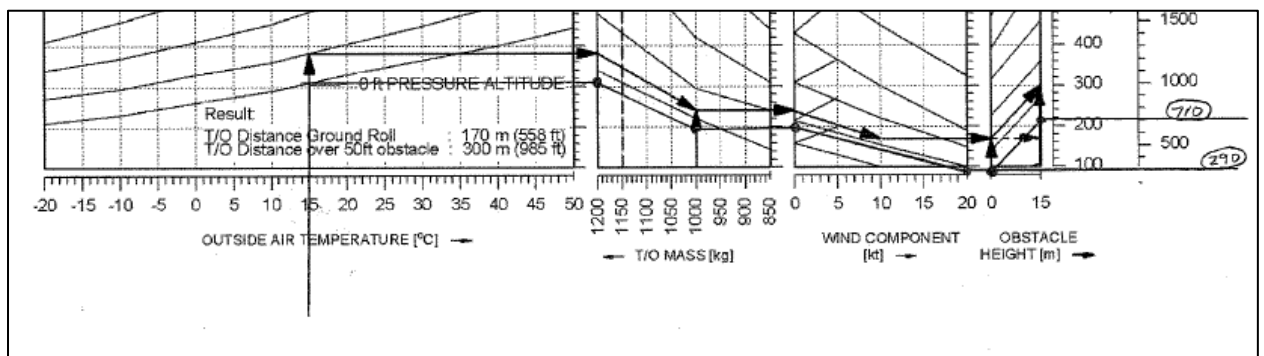


Figure 17. AFM ISA at MSL with 20 Knot Headwind Takeoff Determination

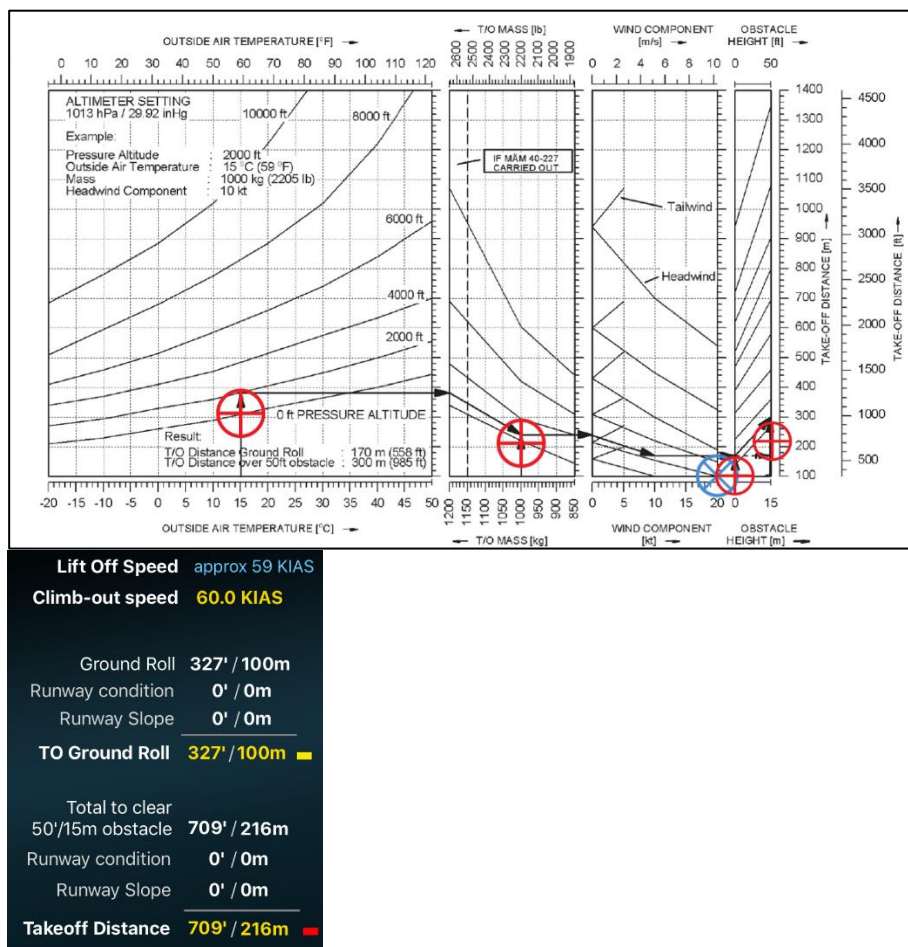


Figure 18. Gyronimo ISA at MSL with 20 Knot Headwind Takeoff Determination

Takeoff Comparison 11: ISA at 5,000 Feet with No Wind

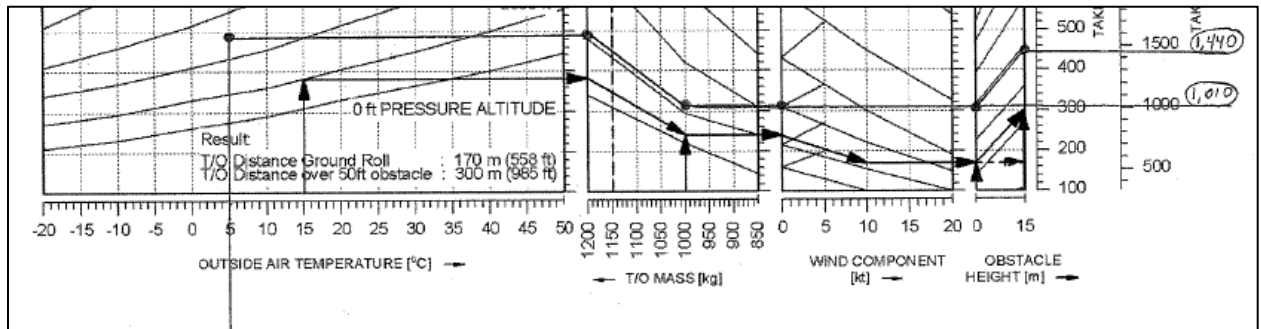
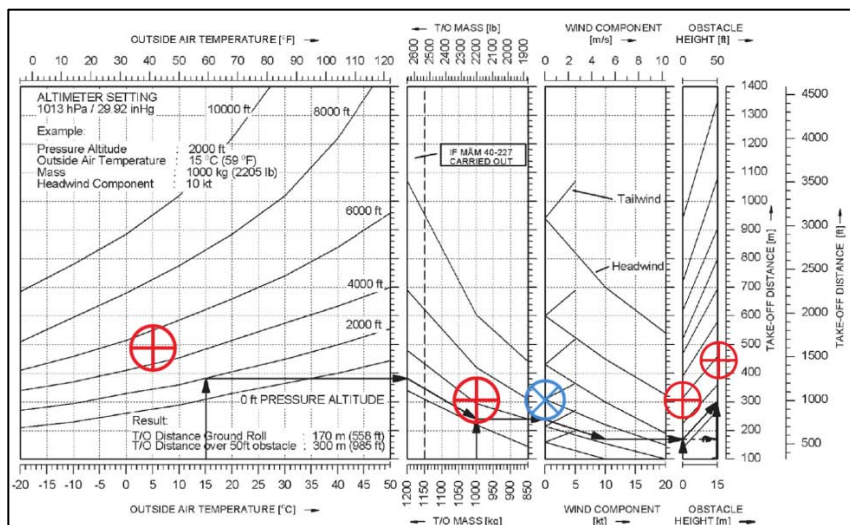


Figure 19. AFM ISA at 5,000 Feet with No Wind Takeoff Determination



Lift Off Speed	approx 59 KIAS
Climb-out speed	60.0 KIAS
Ground Roll	997' / 304m
Runway condition	0' / 0m
Runway Slope	0' / 0m
TO Ground Roll	997' / 304m
Total to clear 50'/15m obstacle	1454' / 443m
Runway condition	0' / 0m
Runway Slope	0' / 0m
Takeoff Distance	1454' / 443m

Figure 20. Gyronimo ISA at MSL with No Wind Takeoff Determination

Takeoff Comparison 12: ISA at 5,000 Feet with 20 Knot Headwind

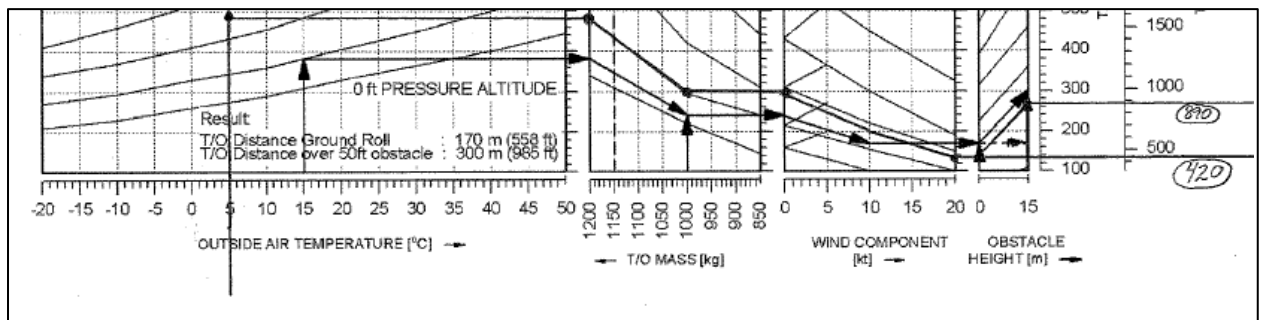


Figure 21. AFM ISA at 5,000 Feet with 20 Knot Headwind Takeoff Determination

14

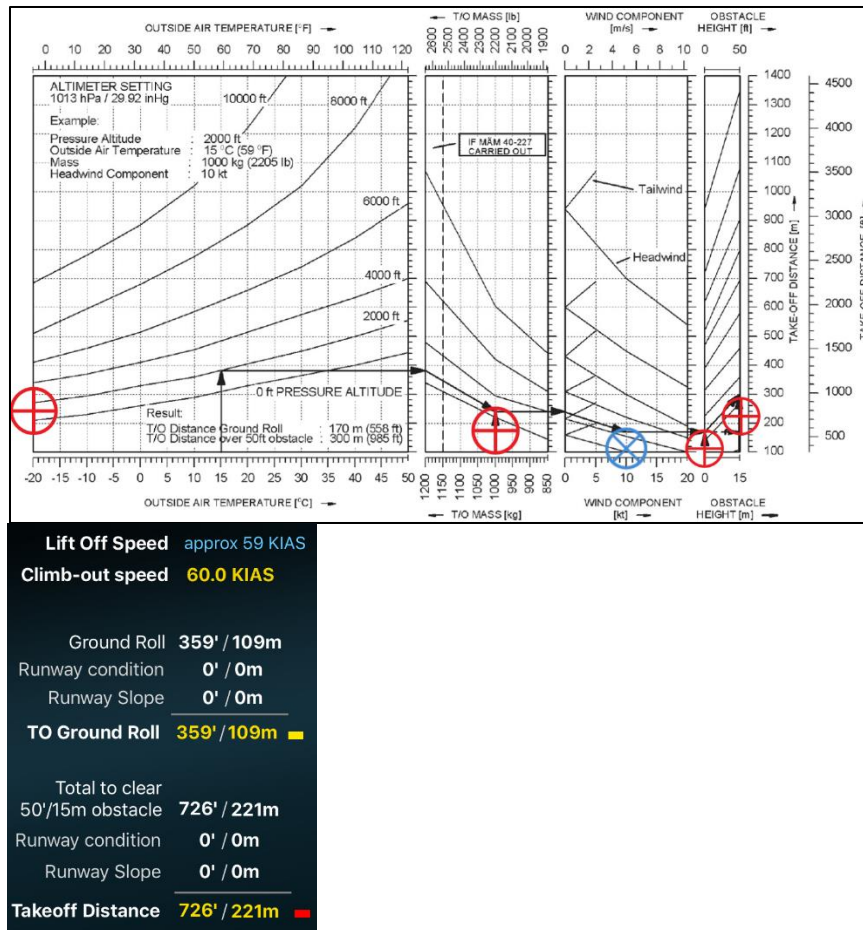


Figure 24. Gyronimo Extreme Low Temperature (Pressure Altitude 1,000 feet) Takeoff Determination

Takeoff Comparison 14: Temperature -5 C and Default Conditions

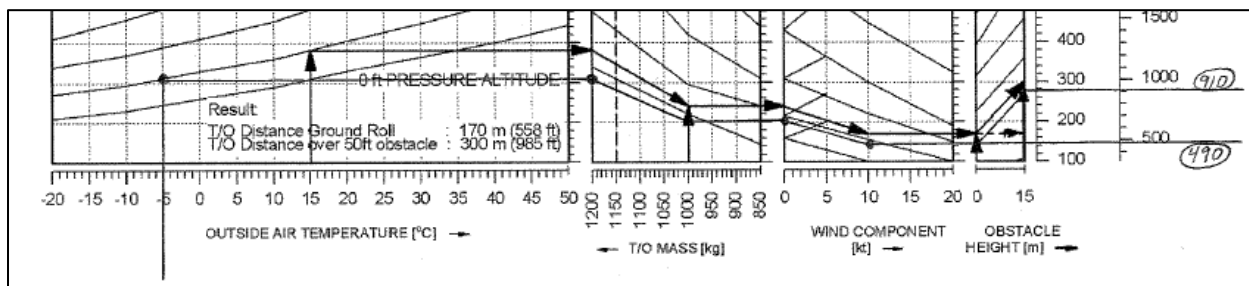
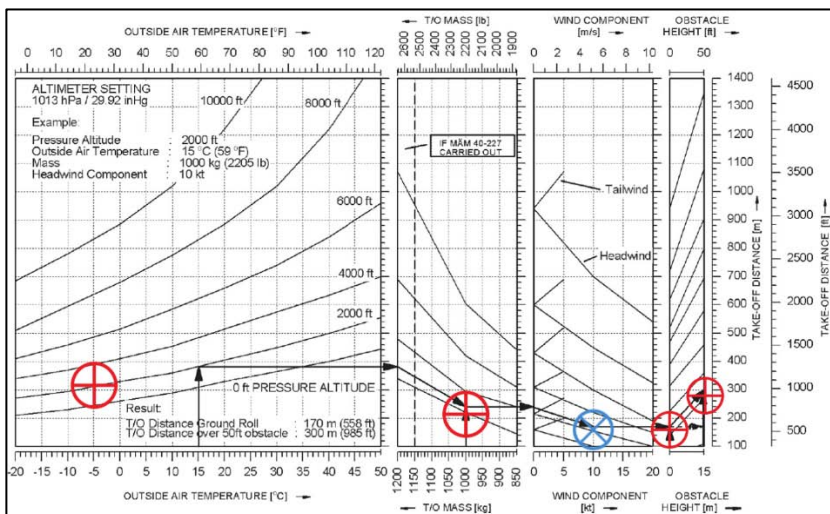


Figure 25. AFM Temperature - 5 Degrees C Takeoff Determination



Lift Off Speed	approx 59 KIAS
Climb-out speed	60.0 KIAS
Ground Roll	512' / 156m
Runway condition	0' / 0m
Runway Slope	0' / 0m
TO Ground Roll	512' / 156m
Total to clear 50'/15m obstacle	908' / 277m
Runway condition	0' / 0m
Runway Slope	0' / 0m
Takeoff Distance	908' / 277m

Figure 26. Gyronimo - 5 Degrees C Takeoff Determination

Takeoff Comparison 15: Temperature 15 Degrees C and Default Conditions

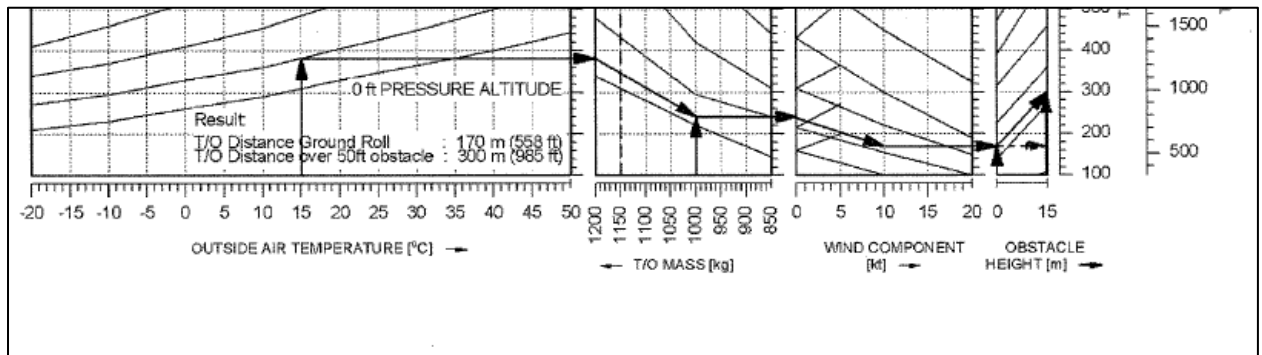


Figure 27. AFM Temperature 15 Degrees C Takeoff Determination

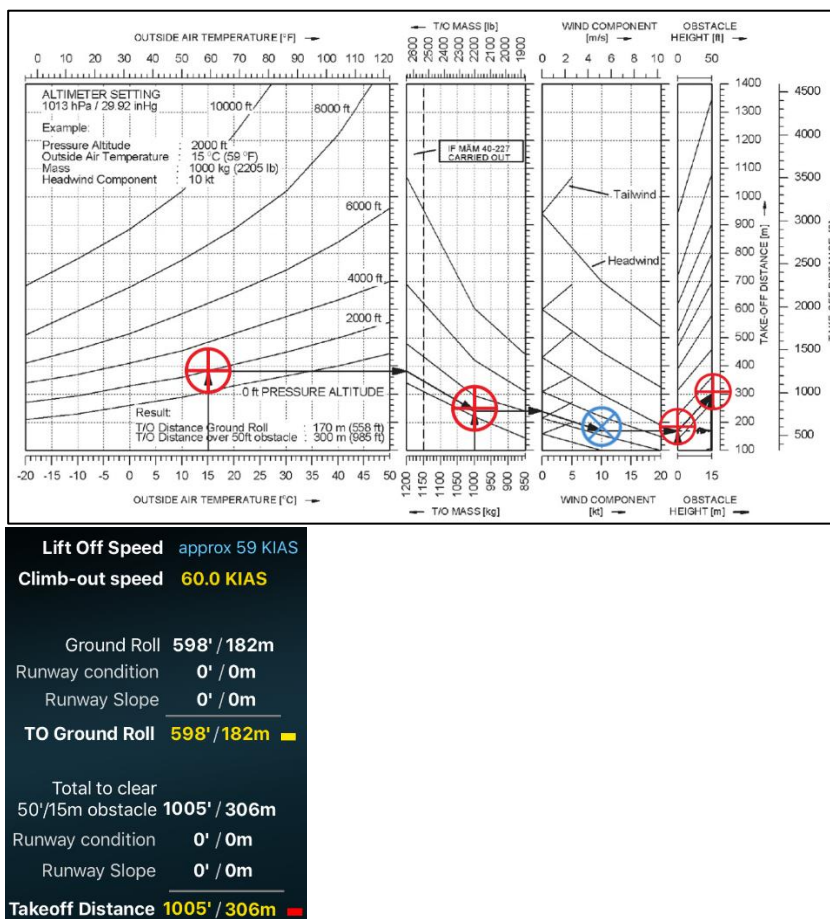


Figure 28. Gyronimo Temperature 15 Degrees C Takeoff Determination

Takeoff Comparison 16: Temperature 30 Degrees C and Default Conditions

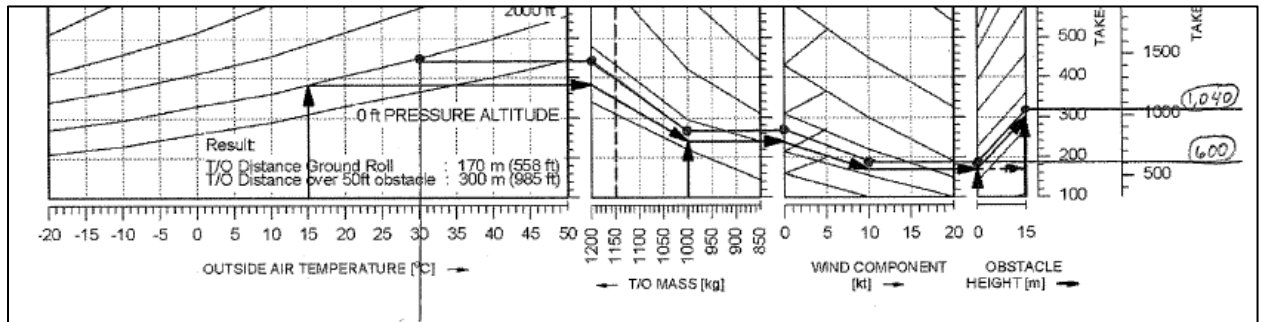
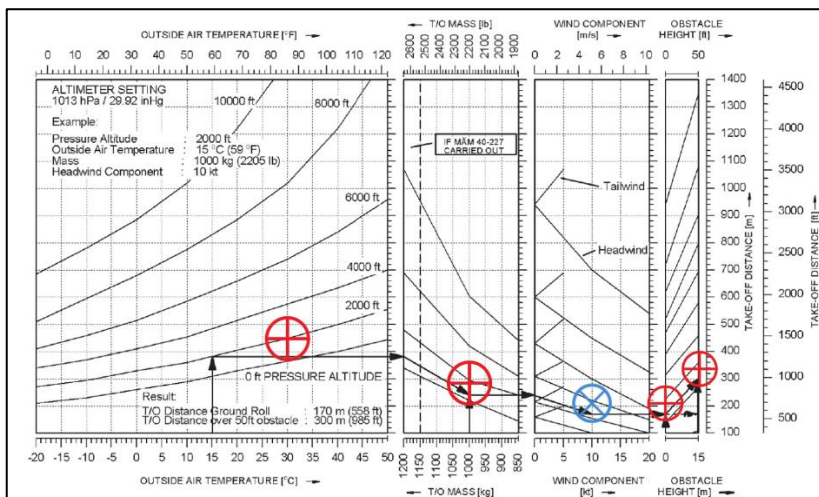


Figure 29. AFM Temperature 30 Degrees C Takeoff Determination



Lift Off Speed approx 59 KIAS
Climb-out speed 60.0 KIAS

 Ground Roll 679' / 207m
 Runway condition 0' / 0m
 Runway Slope 0' / 0m
TO Ground Roll 679' / 207m

 Total to clear
 50'/15m obstacle 1096' / 334m
 Runway condition 0' / 0m
 Runway Slope 0' / 0m
Takeoff Distance 1096' / 334m

Figure 30. Gyronimo Temperature 30 Degrees C Takeoff Determination

Takeoff Comparison 17: Pressure Altitude 1,000 Feet Takeoff Comparison

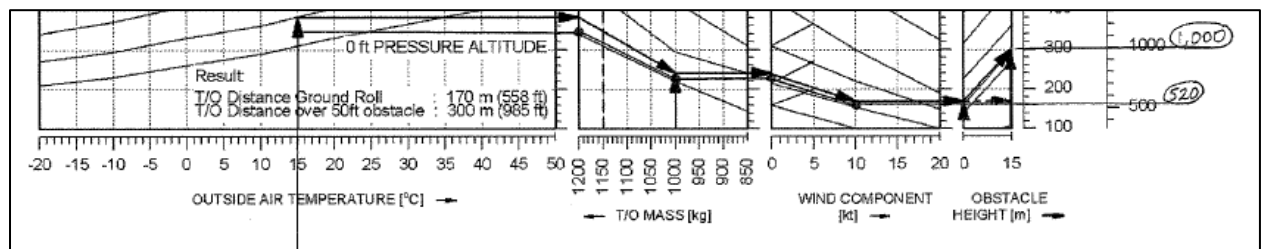


Figure 31. AFM Pressure Altitude 1,000 Feet Takeoff Determination

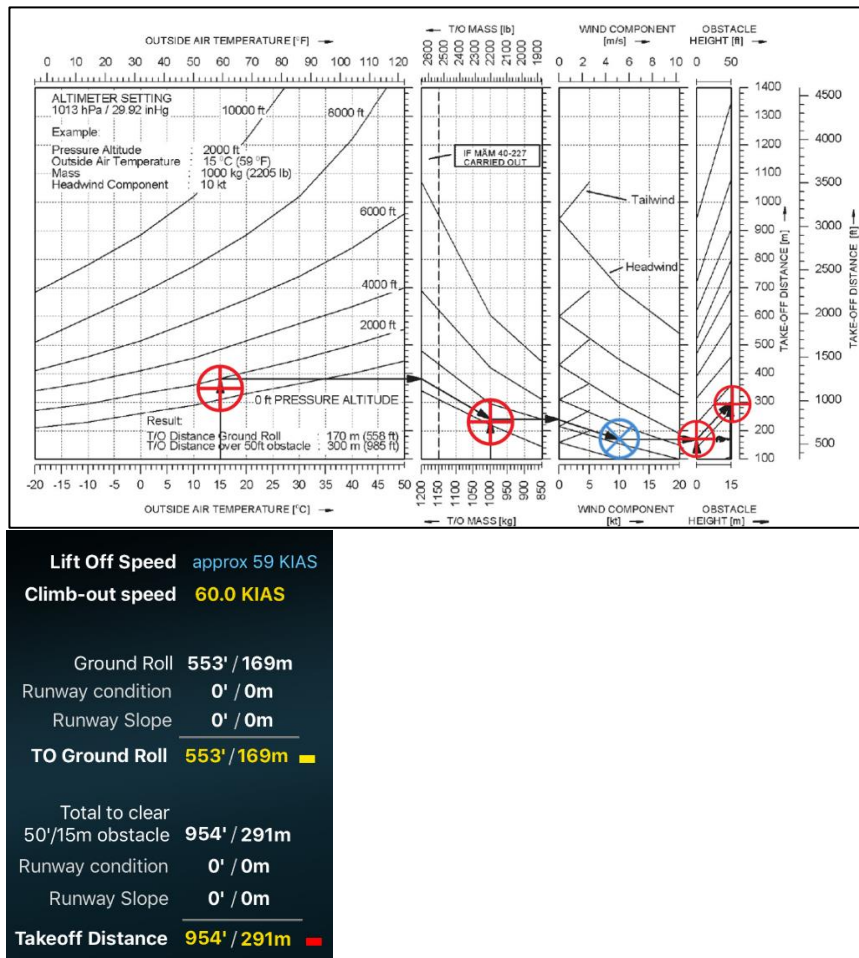


Figure 32. Gyronimo Pressure Altitude 1,000 Feet Takeoff Determination

Takeoff Comparison 18: Pressure Altitude 4,000 Feet Takeoff Comparison

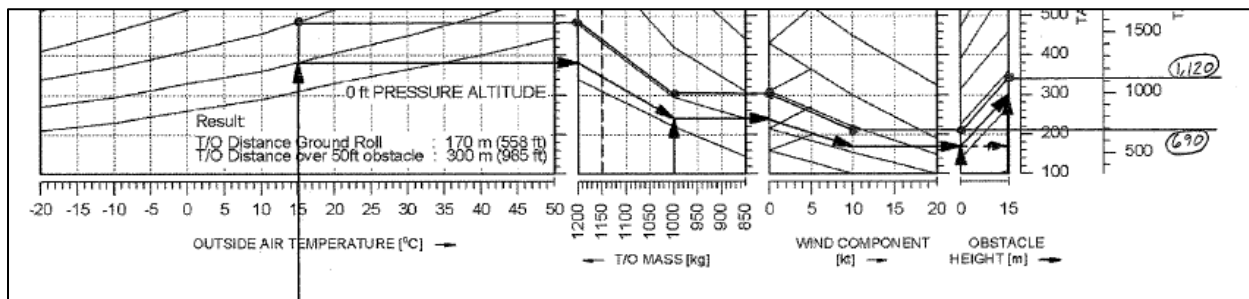


Figure 33. AFM Pressure Altitude 4,000 Feet Takeoff Determination

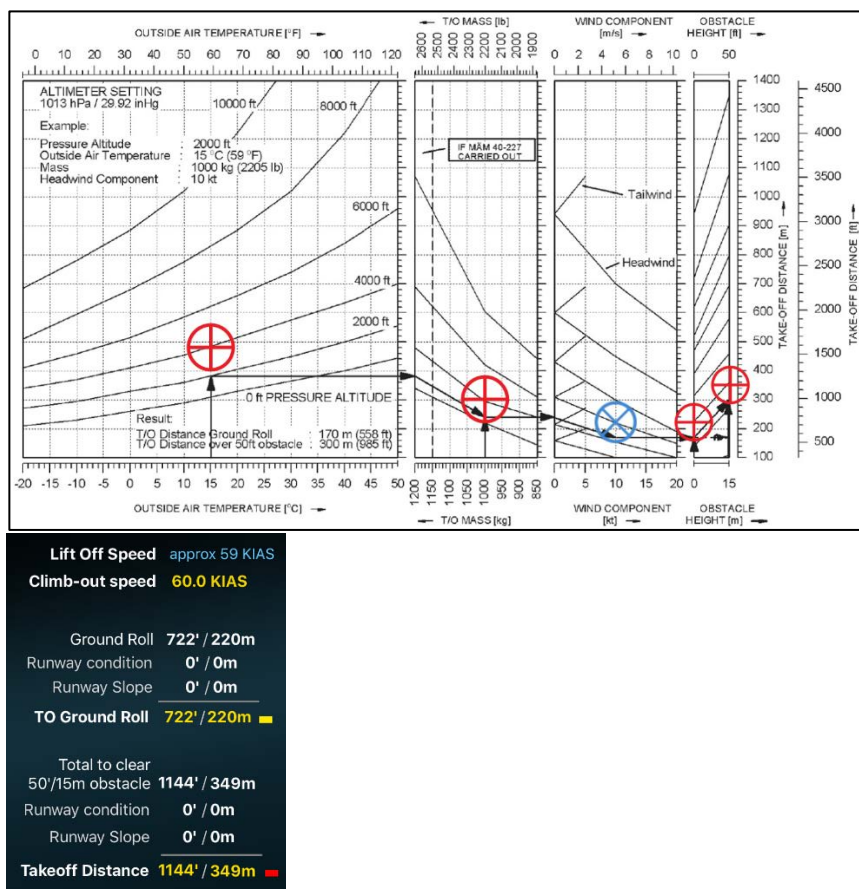


Figure 34. Gyronimo Pressure Altitude 4,000 Feet Takeoff Determination

Takeoff Comparison 19: Pressure Altitude 8,000 Feet Takeoff Comparison

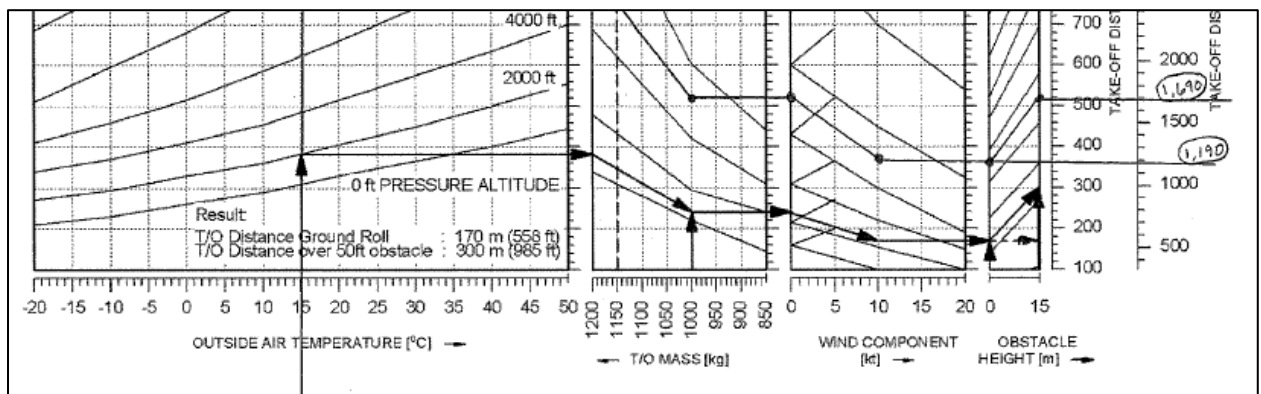


Figure 35. AFM Pressure Altitude 8,000 Feet Takeoff Determination

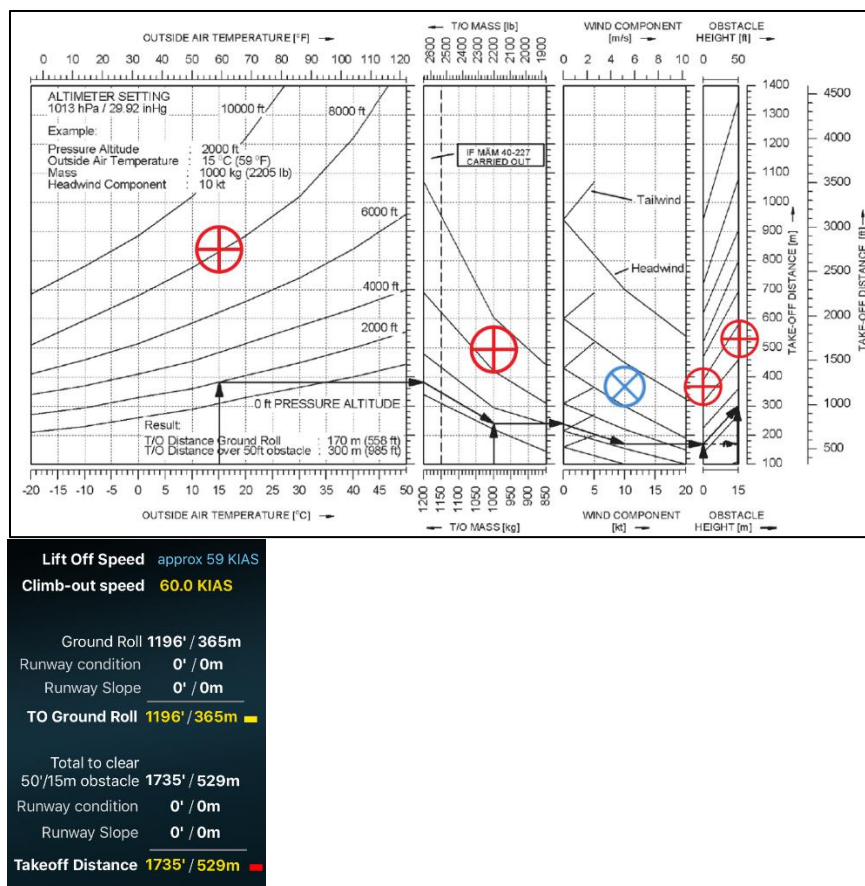


Figure 36. Gyronimo Pressure Altitude 8,000 Feet Takeoff Determination

Takeoff Comparison 20: Weight 2,000 Pounds Takeoff Comparison

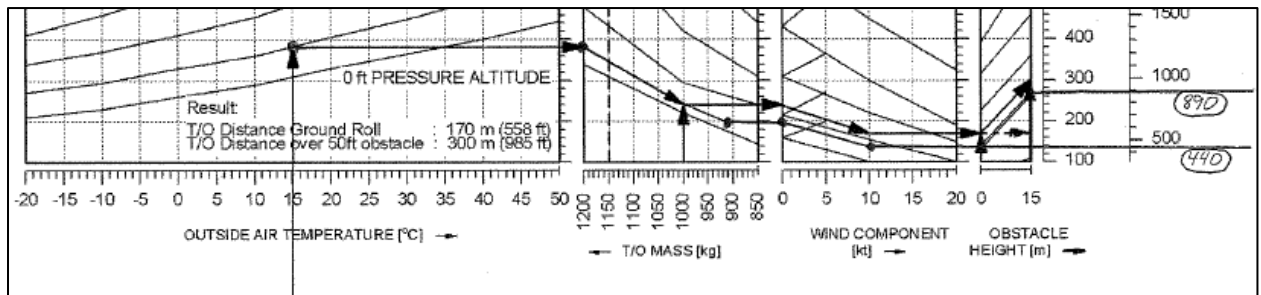


Figure 37. AFM Weight 2,000 Pounds Takeoff Determination

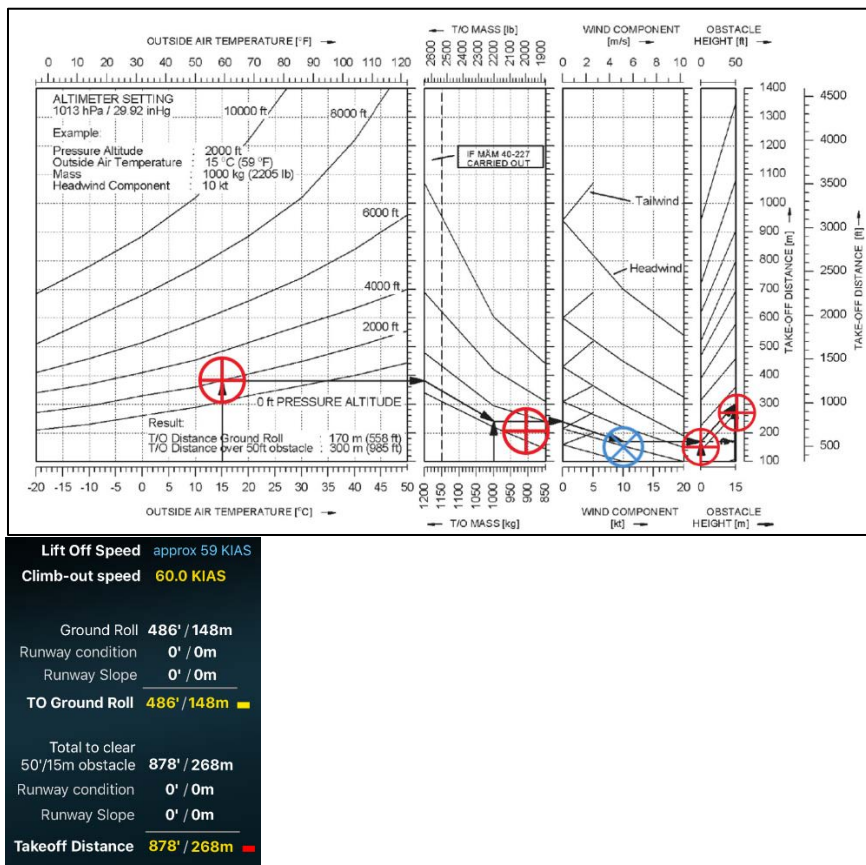


Figure 38. Gyronimo Weight 2,000 Pounds Takeoff Determination

Takeoff Comparison 21: Weight 2,400 Pounds Takeoff Comparison

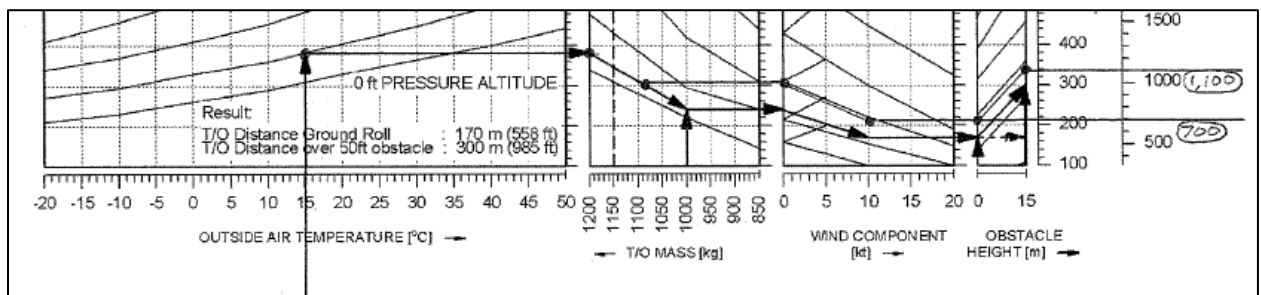


Figure 39. AFM Weight 2,400 Pounds Takeoff Determination

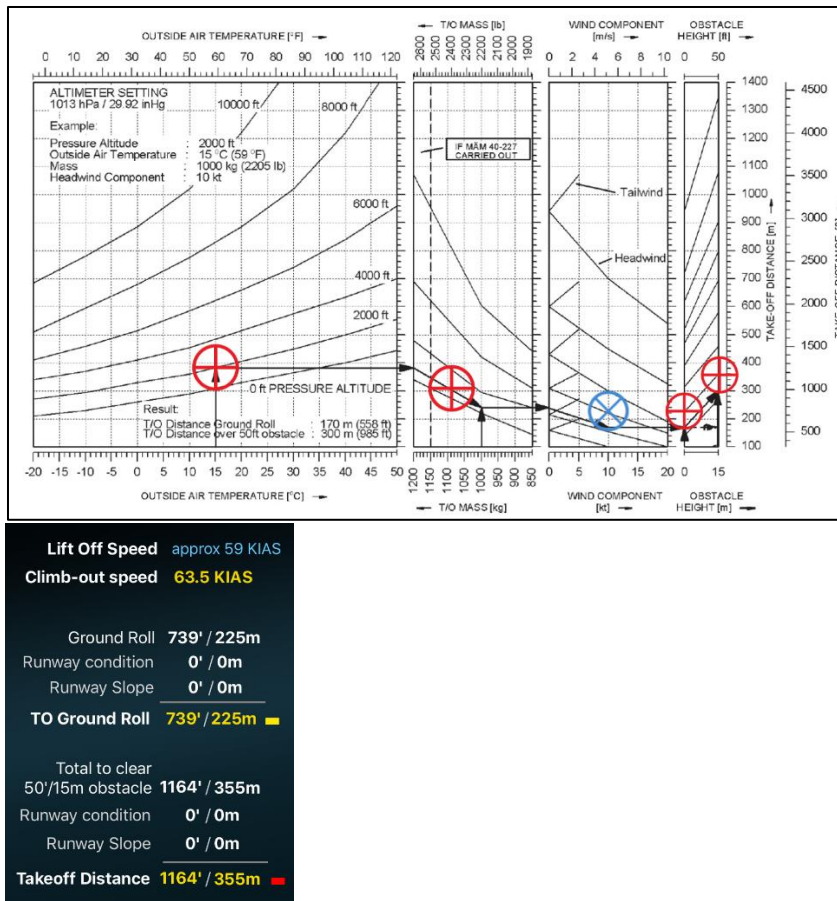


Figure 40. Gyronimo Weight 2,400 Pounds Takeoff Determination

Takeoff Comparison 22: Weight 2,600 Pounds Takeoff Comparison

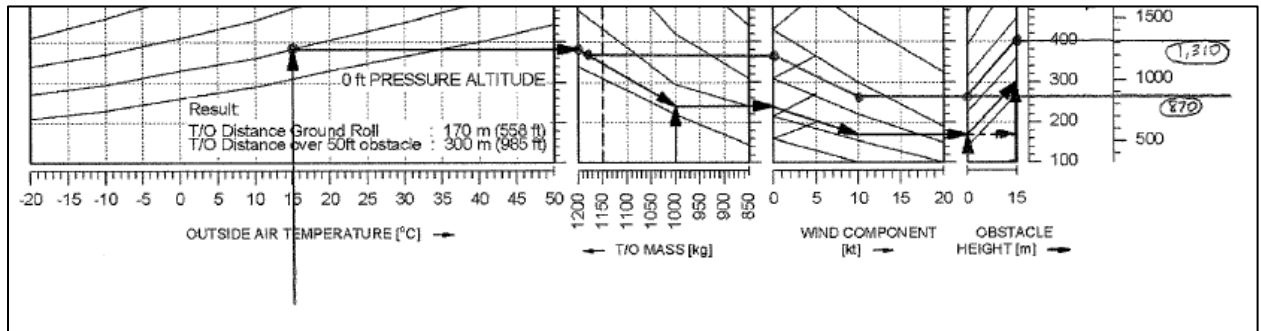
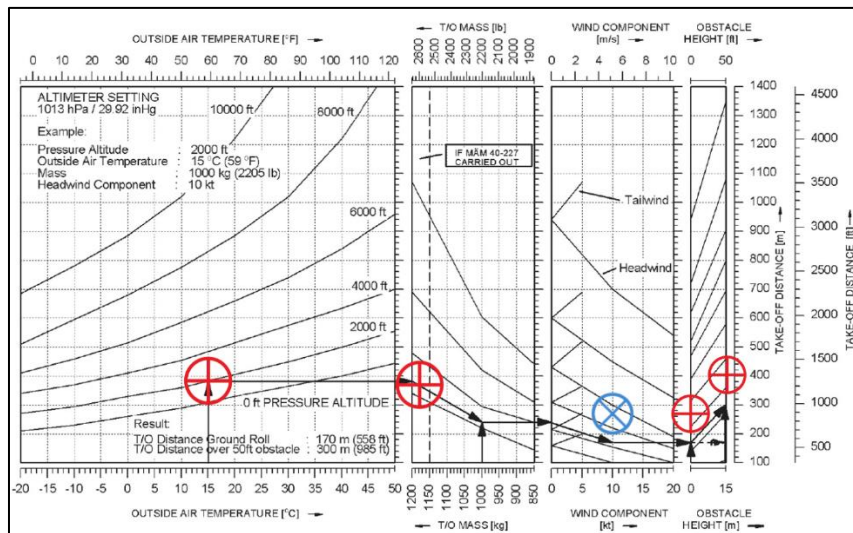


Figure 41. AFM Weight 2,600 Pounds Takeoff Determination



Lift Off Speed	approx 59 KIAS
Climb-out speed	66.6 KIAS
Ground Roll	877' / 267m
Runway condition	0' / 0m
Runway Slope	0' / 0m
TO Ground Roll	877' / 267m
Total to clear 50'/15m obstacle	1318' / 402m
Runway condition	0' / 0m
Runway Slope	0' / 0m
Takeoff Distance	1318' / 402m

Figure 42. Gyronimo Weight 2,600 Pounds Takeoff Determination

Takeoff Comparison 23: 7 Knot Headwind Takeoff Comparison

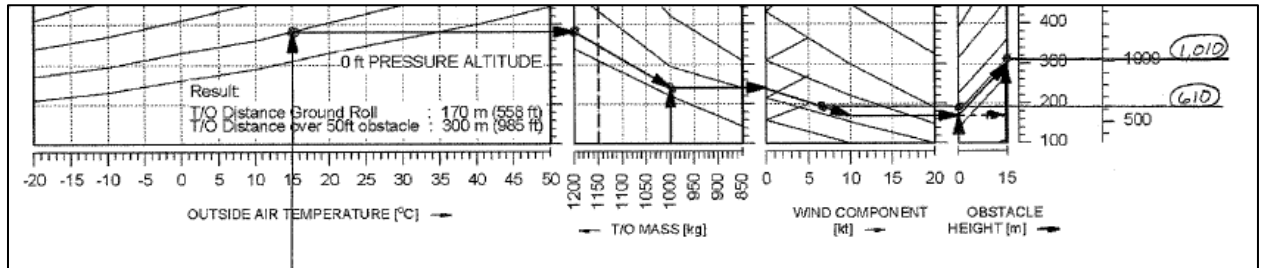


Figure 43. AFM 7 Knot Headwind Takeoff Determination

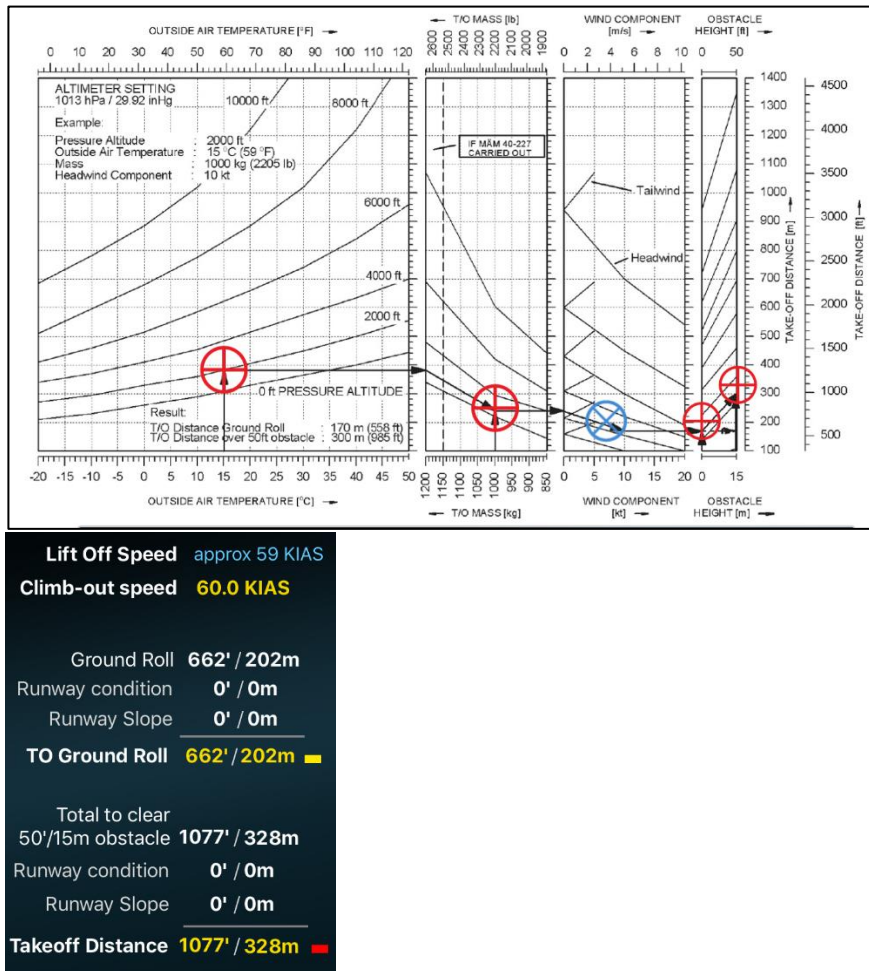


Figure 44. Gyronimo 7 Knot Headwind Takeoff Determination

Takeoff Comparison 24: 14 Knot Headwind Takeoff Comparison

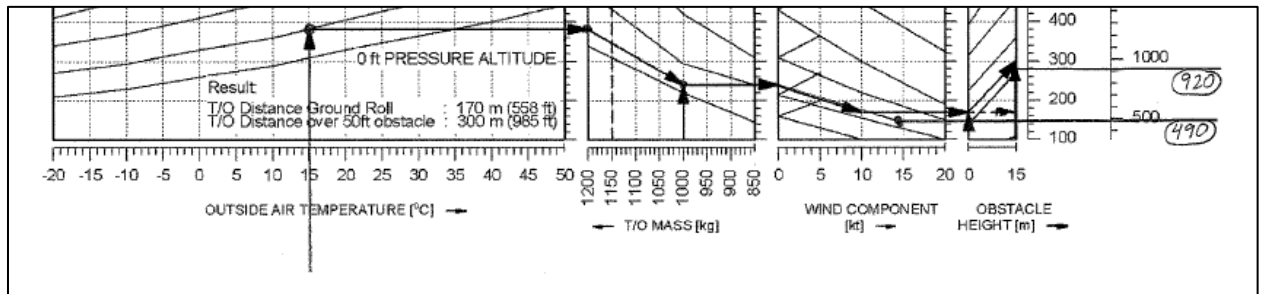


Figure 45. AFM 14 Knot Headwind Takeoff Determination

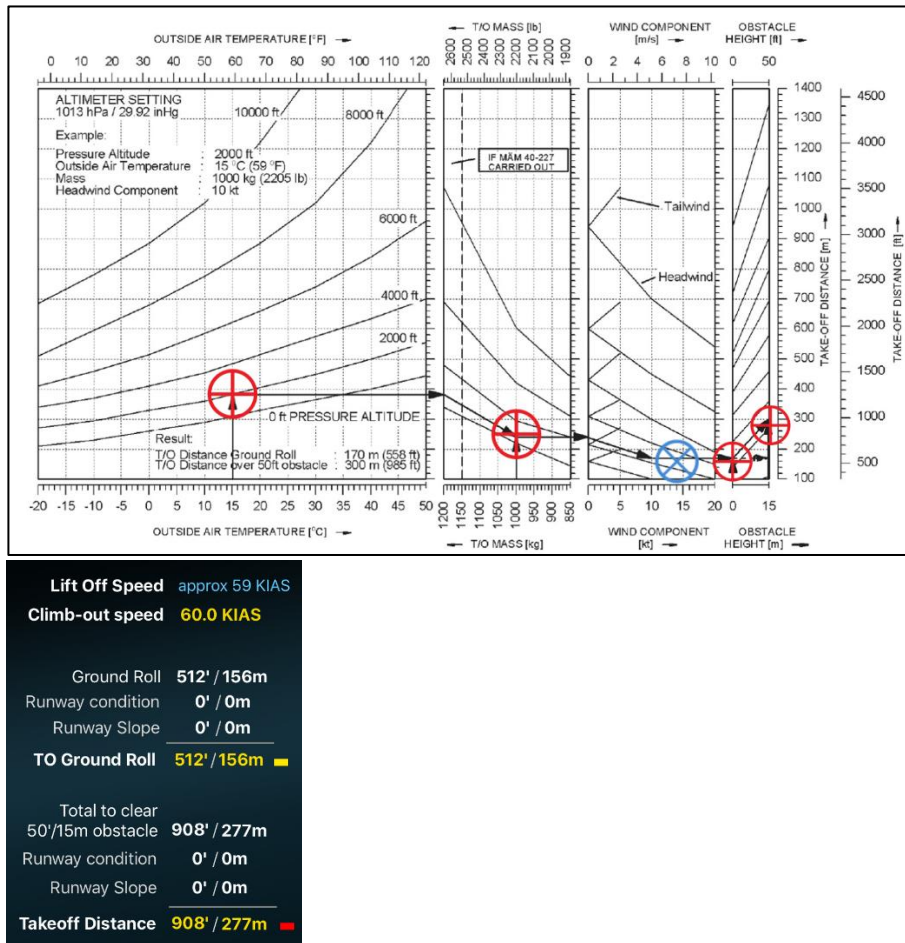


Figure 46. Gyronimo 14 Knot Headwind Takeoff Determination

Takeoff Comparison 25: 20Knot Headwind Takeoff Comparison

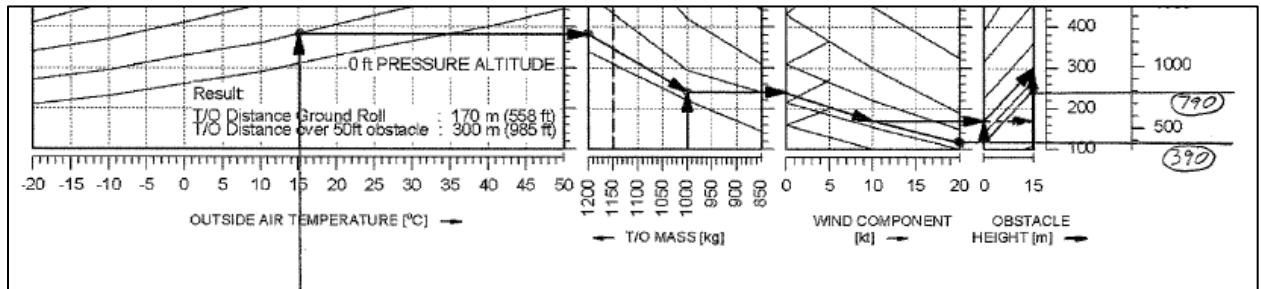
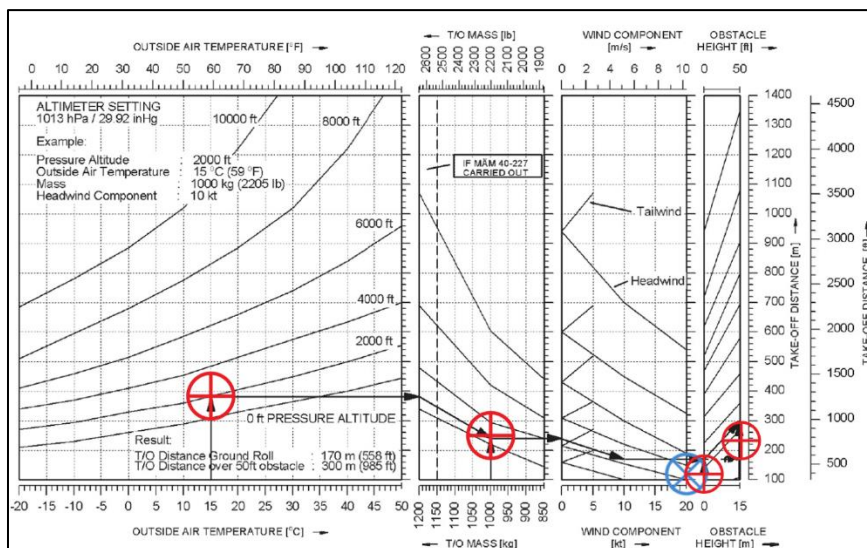


Figure 47. AFM 20 Knot Headwind Takeoff Determination



Lift Off Speed	approx 59 KIAS
Climb-out speed	60.0 KIAS
Ground Roll	384' / 117m
Runway condition	0' / 0m
Runway Slope	0' / 0m
TO Ground Roll	384' / 117m
Total to clear 50'/15m obstacle	756' / 230m
Runway condition	0' / 0m
Runway Slope	0' / 0m
Takeoff Distance	756' / 230m

Figure 48. Gyronimo 20 Knot Headwind Takeoff Determination

Appendix B: Landing Performance Chart Comparisons

Landing Comparison 1: AFM Default Information

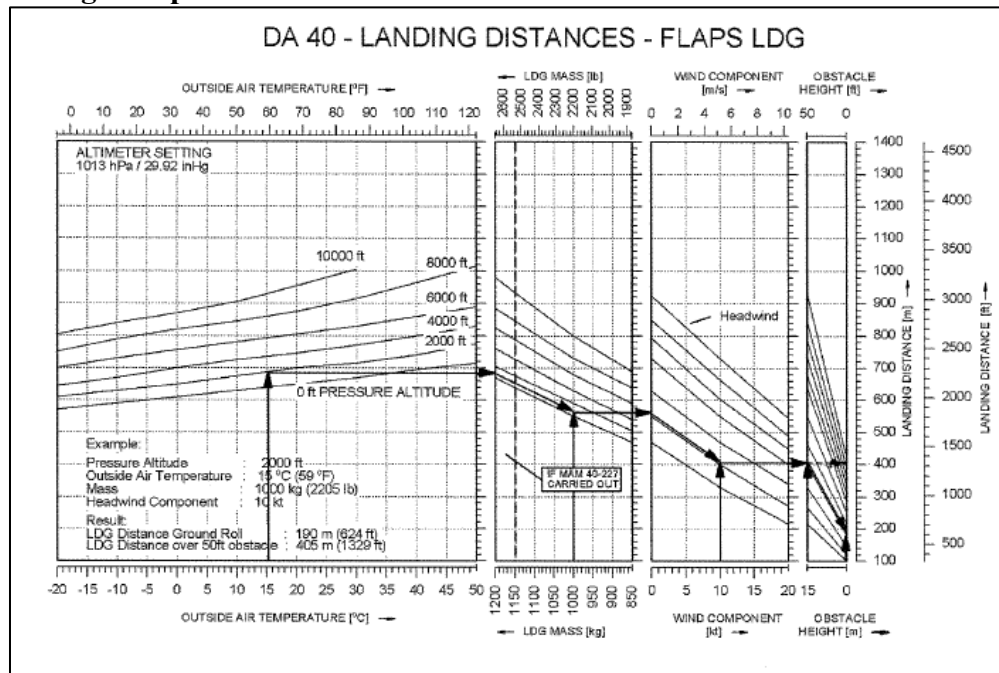


Figure 1. AFM Default Variables Landing Determination

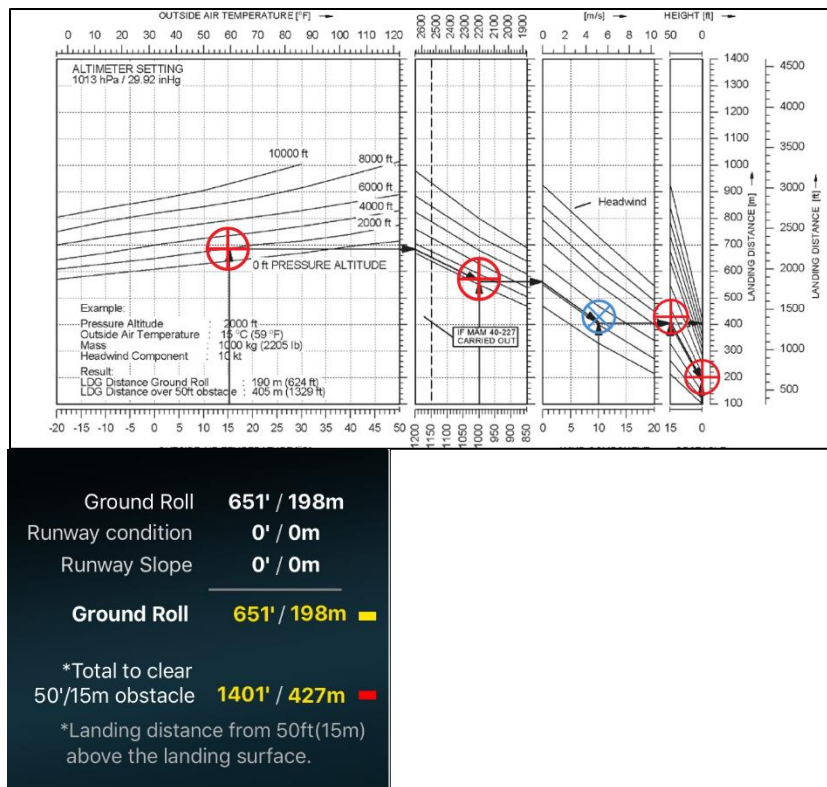


Figure 2. Gyronimo Default Variables Landing Determination

Landing Comparison 2: Maximum Gross Weight

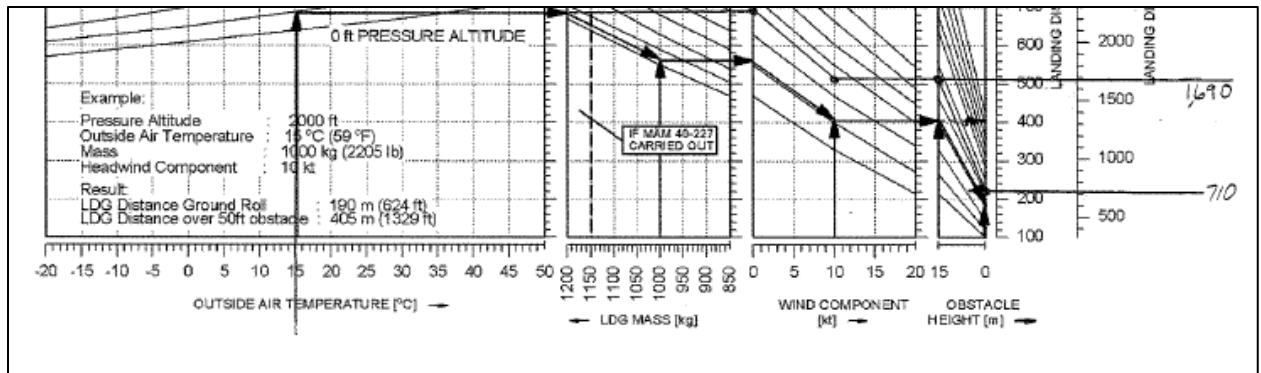


Figure 3. AFM Maximum Gross Weight Landing Determination

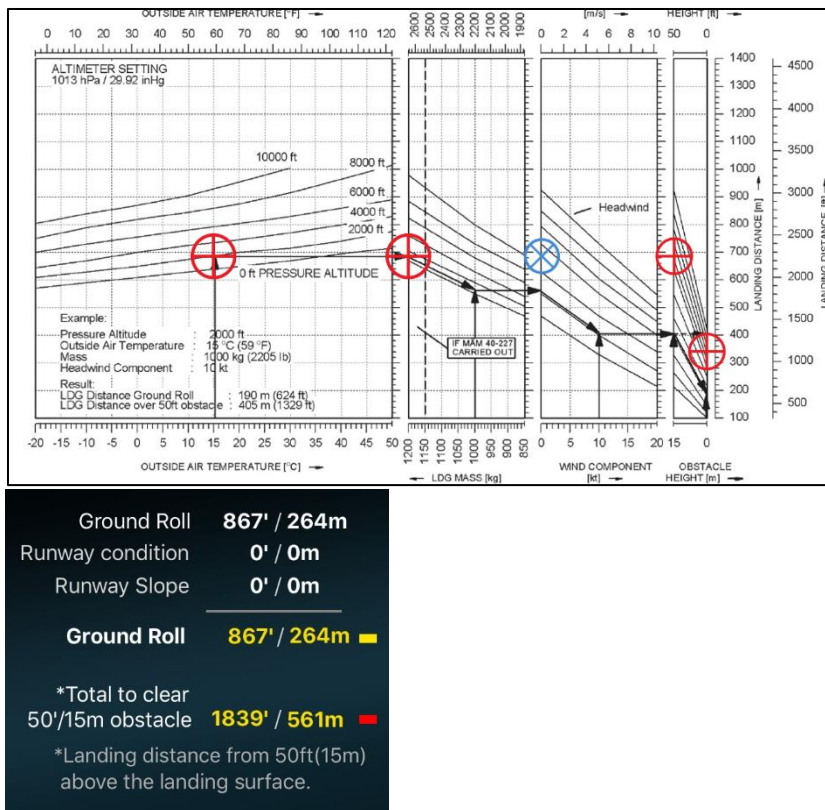


Figure 4. Gyronimo Maximum Gross Weight Landing Determination

Landing Comparison 3: Maximum Pressure Altitude (10,000 feet)

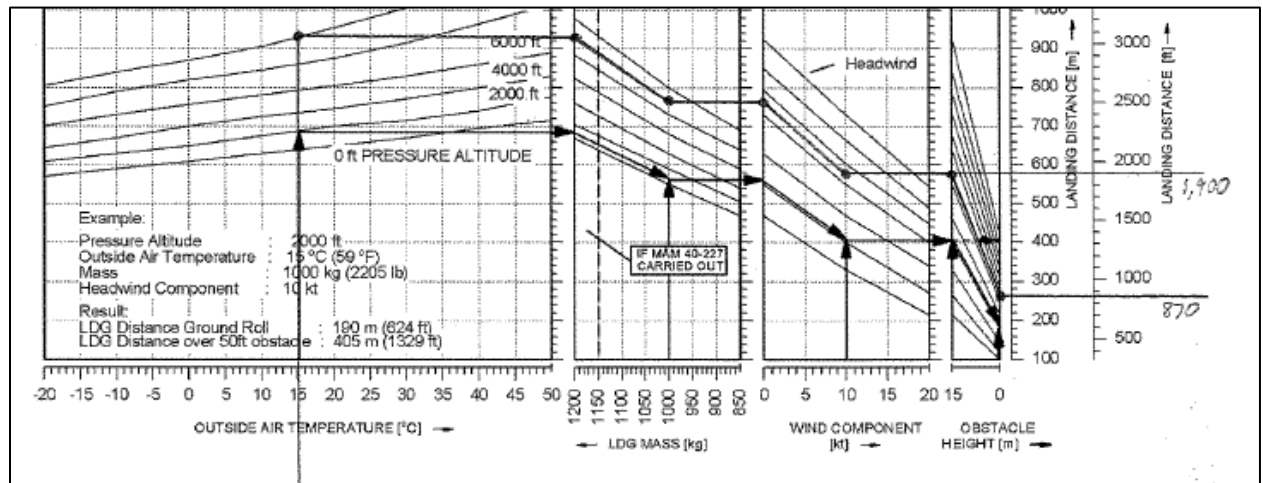


Figure 5. AFM Maximum Pressure Altitude Landing Determination

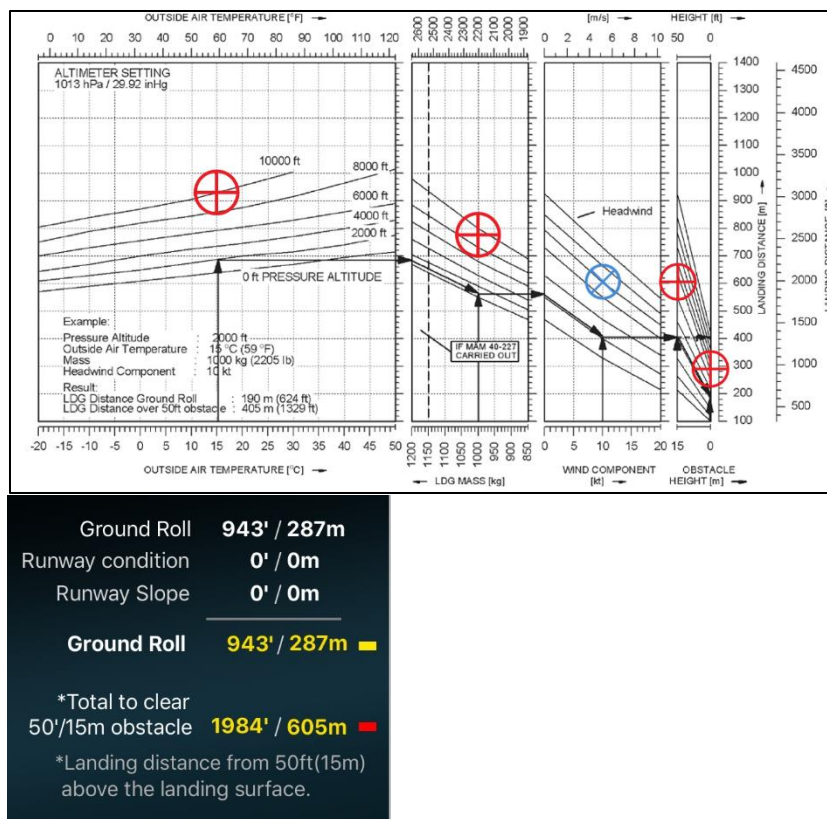


Figure 6. Gyronimo Maximum Pressure Altitude Landing Determination

Landing Comparison 4: Maximum OAT (50 degrees C)

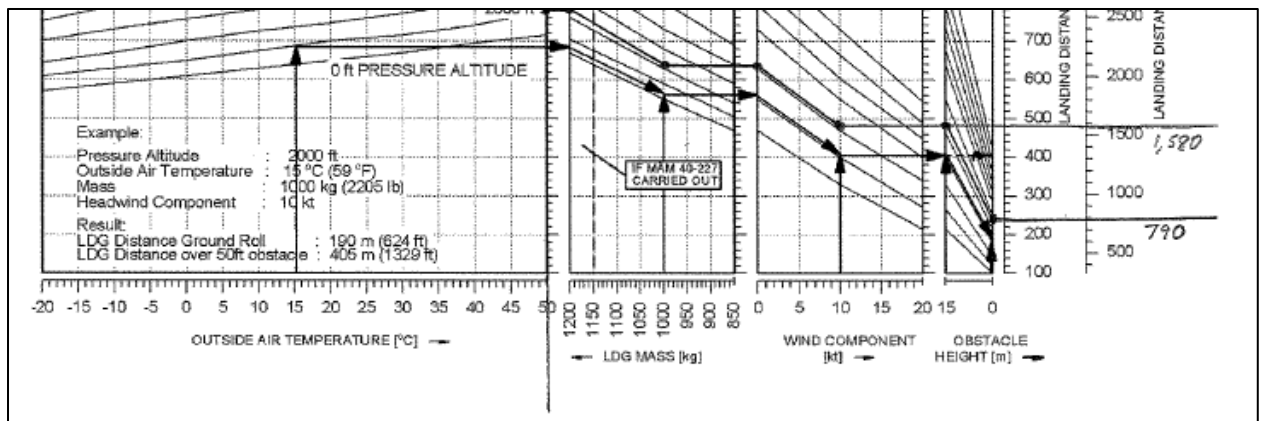


Figure 7. AFM Maximum OAT Landing Determination

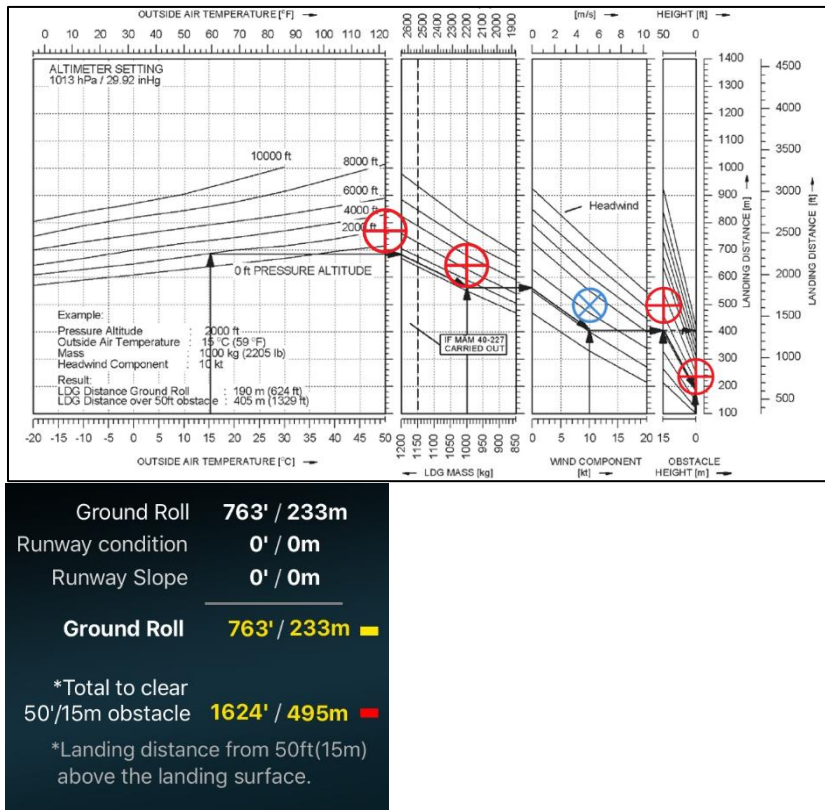


Figure 8. Gyronimo Maximum OAT Landing Determination

Landing Comparison 5: Hot and High Landing Determination (EASA)

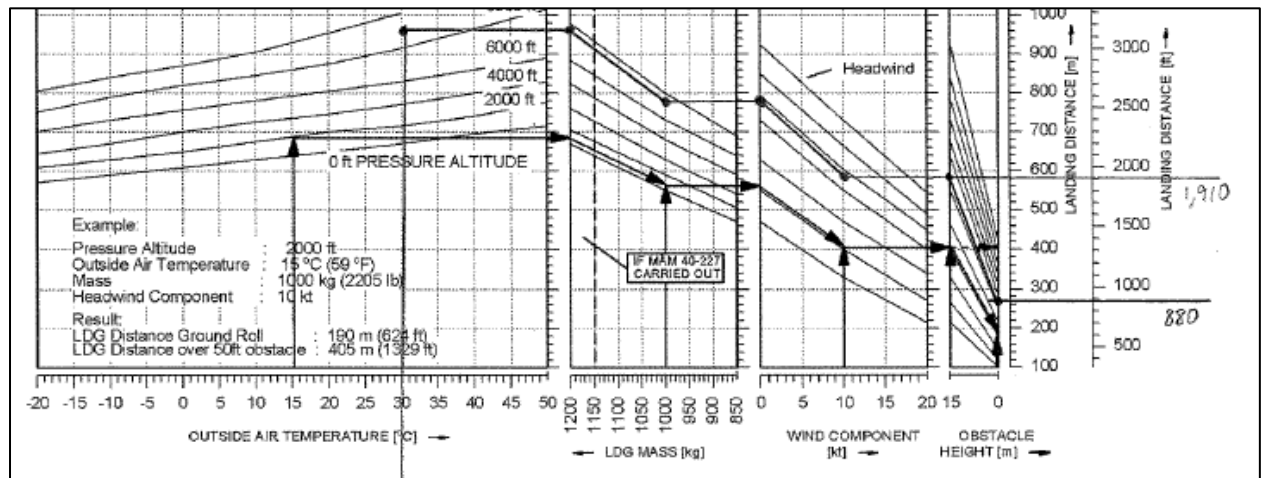


Figure 9. AFM Hot and High Landing Determination

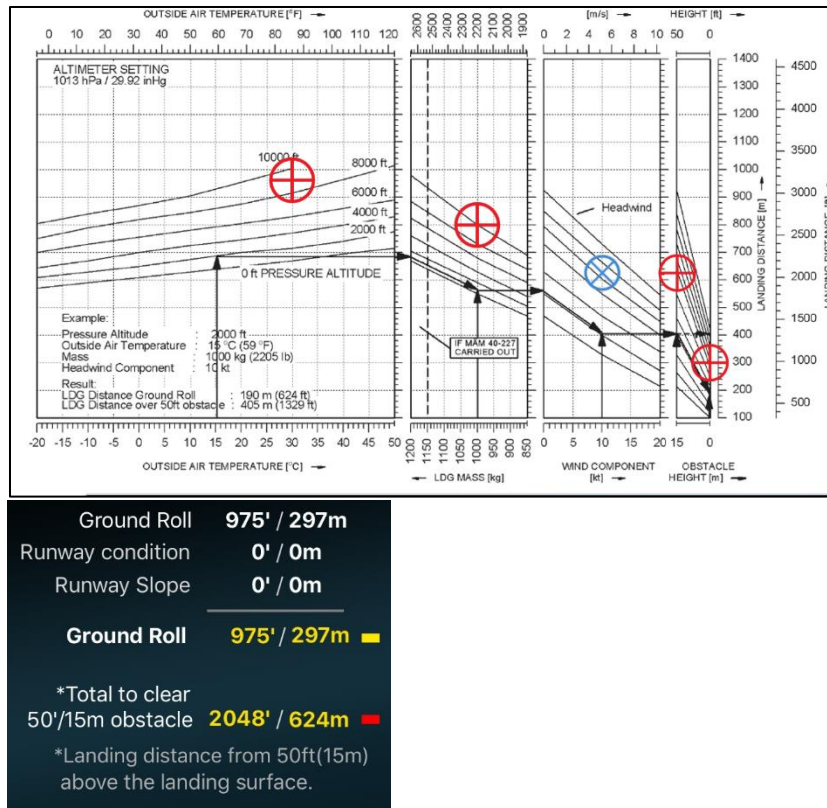


Figure 10. Gyronimo Hot and High Landing Determination

Landing Comparison 6: ISA Condition (MSL) with No Wind

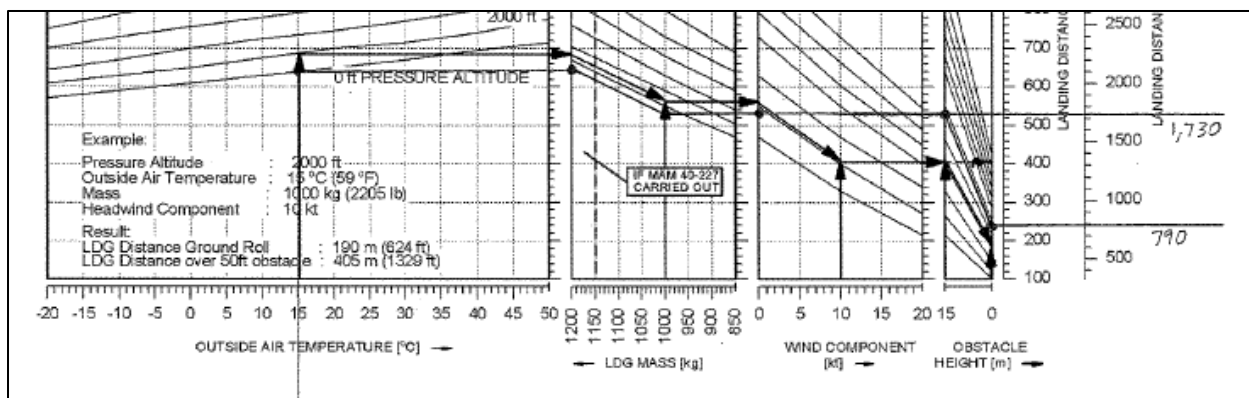


Figure 11. AFM Landing Determination at ISA with No Wind

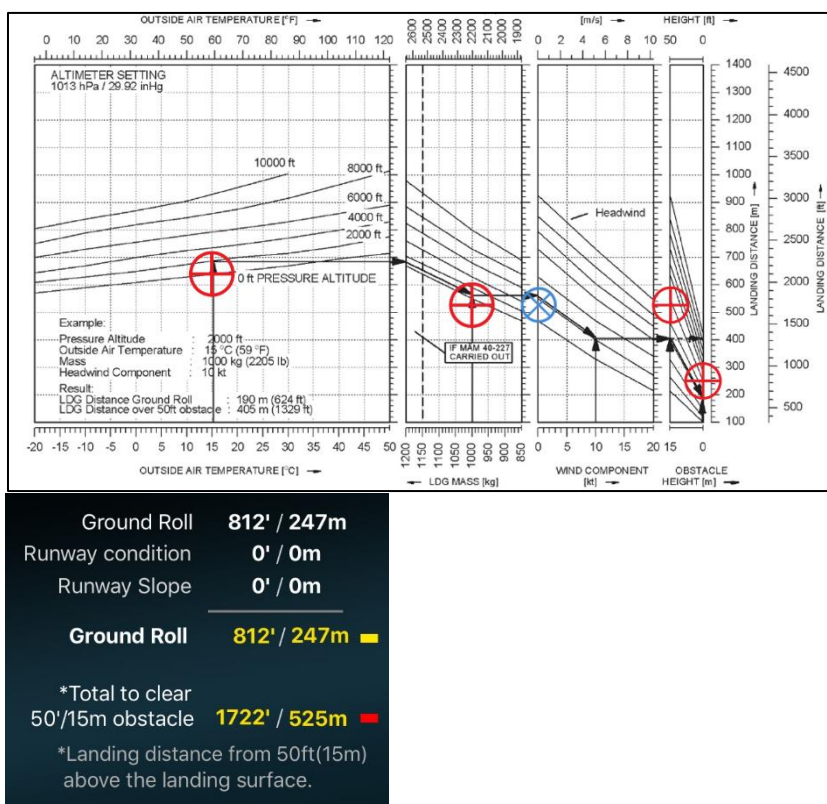


Figure 21. Gyronimo Landing Determination at ISA with No Wind

Landing Comparison 7: ISA Condition (MSL) with 20 Knot Headwind

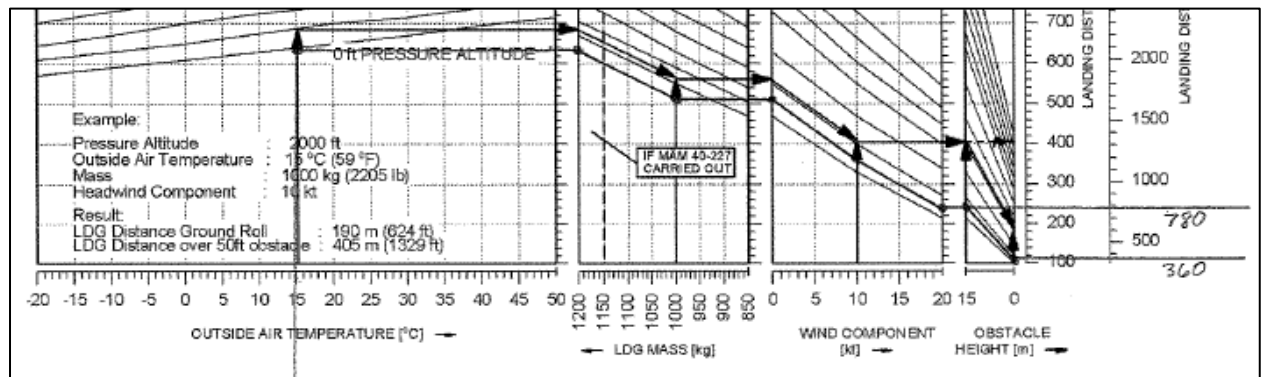


Figure 13. Gyronimo Default Landing at ISA with 20 Knot Headwind



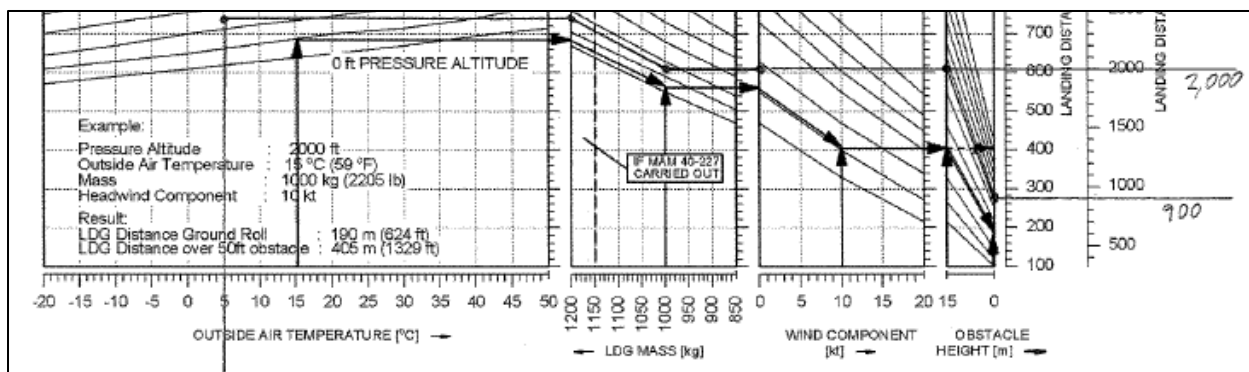


Figure 14. AFM Hot at ISA Condition (5,000 feet) with No Wind

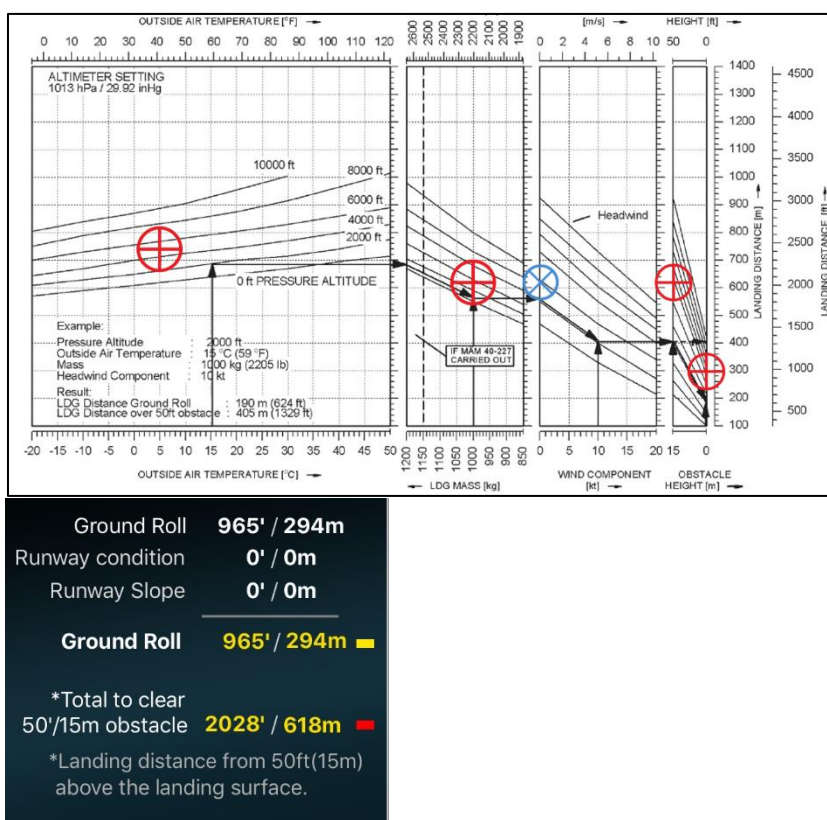


Figure 15. Gyronimo Hot ISA Condition (5,000 feet) with No Wind

Landing Comparison 9: ISA Condition (5,000 feet) with 20 Knot Headwind

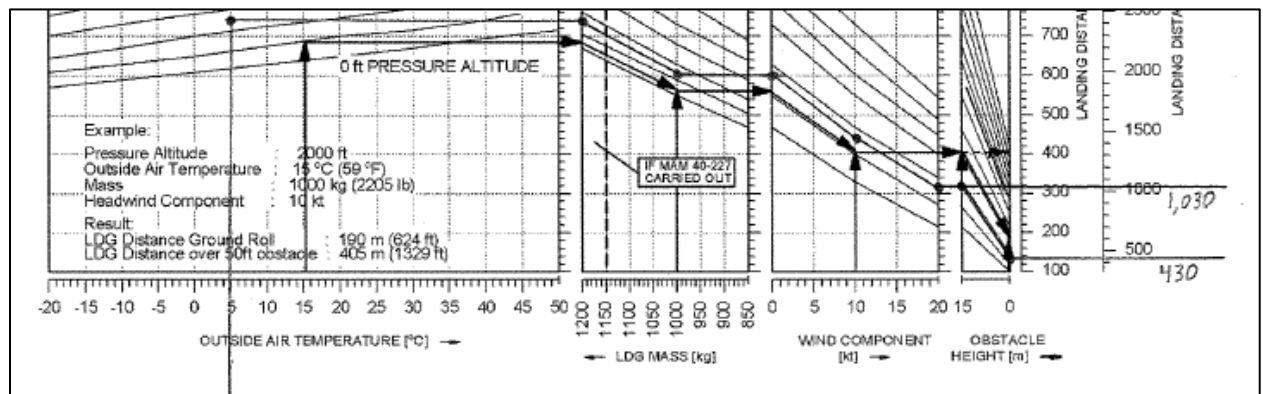


Figure 16. AFM ISA at 5,000 feet with 20 Knot Headwind Landing Determination

Landing Comparison 10: Extreme Low Temperature

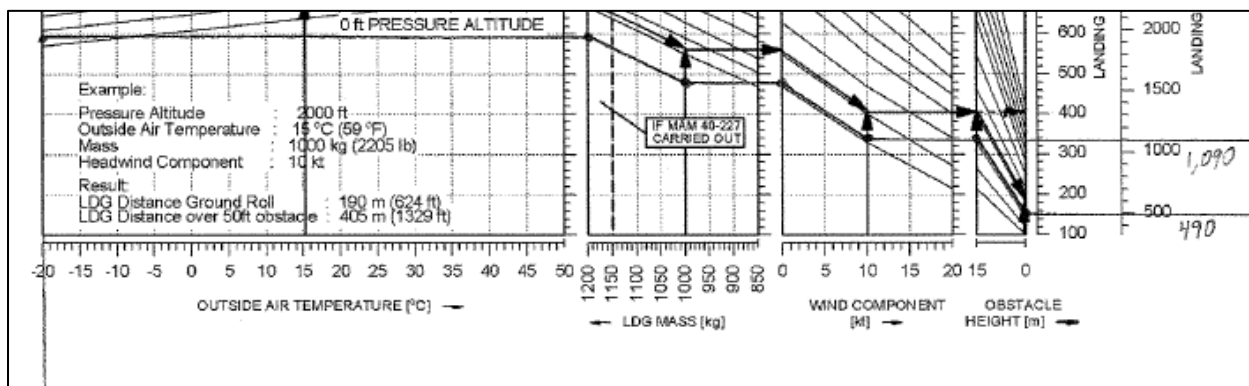


Figure 18. AFM Extreme Low Temperature Landing Determination

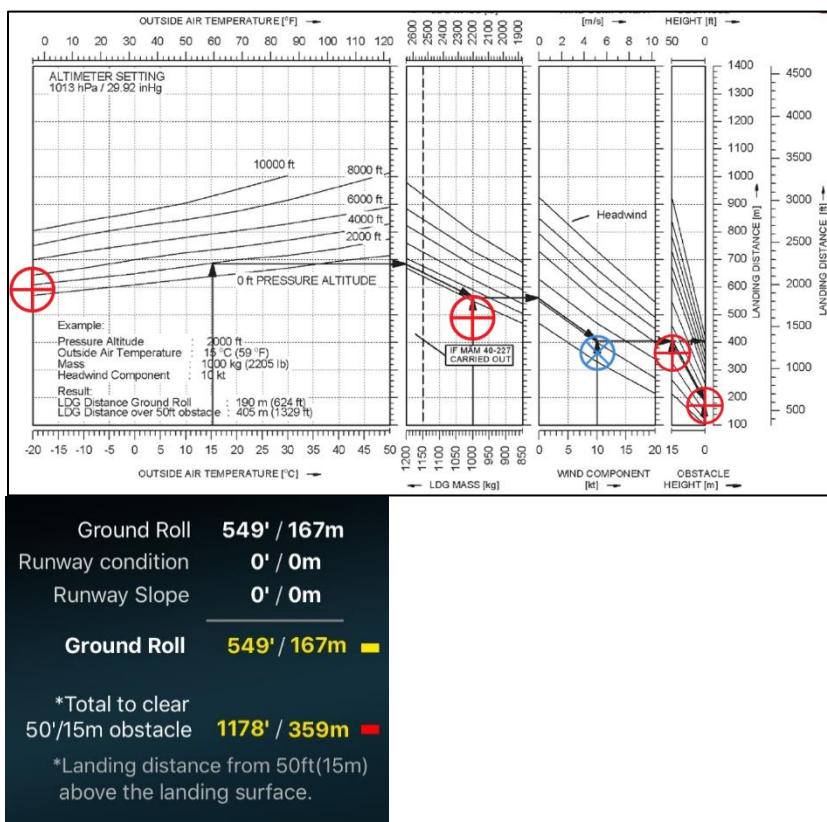


Figure 19. Gyronimo Extreme Low Temperature Landing Determination

Landing Comparison 11: Temperature – 5 C

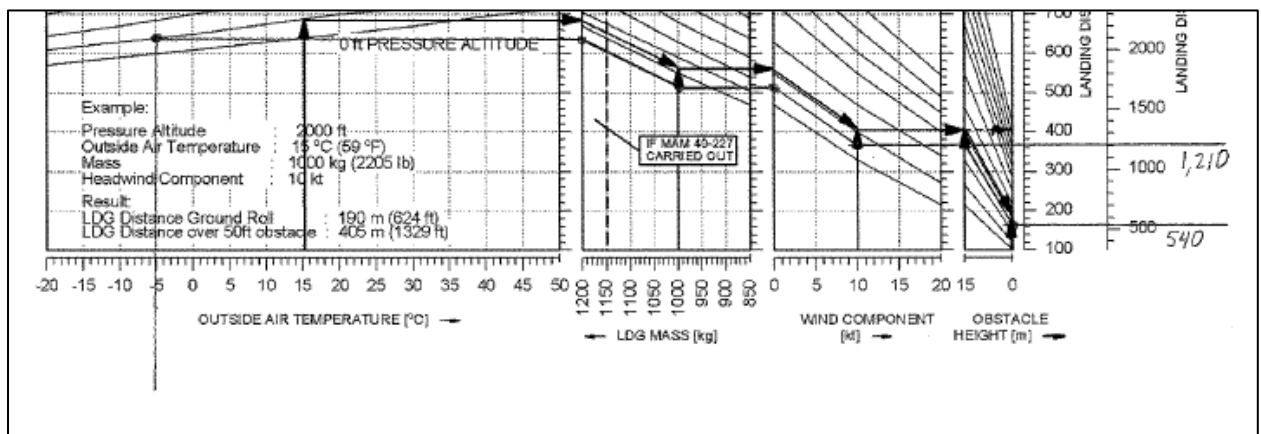


Figure 20. AFM Temperature – 5 C Landing Determination

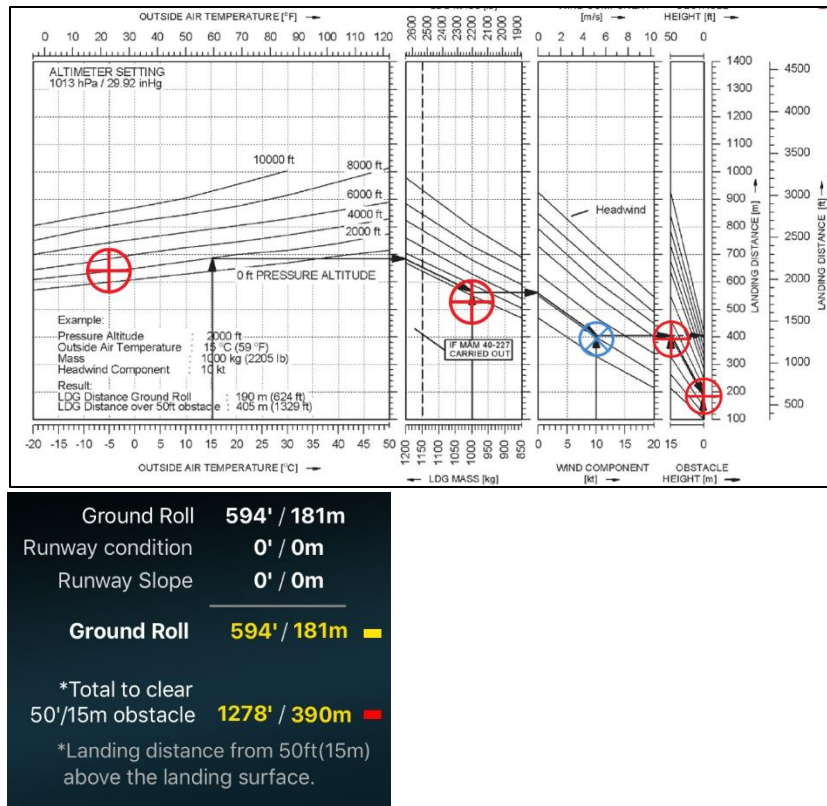


Figure 21. Gyronimo Temperature – 5 C Landing Determination

Landing Comparison 12: Temperature 15 C

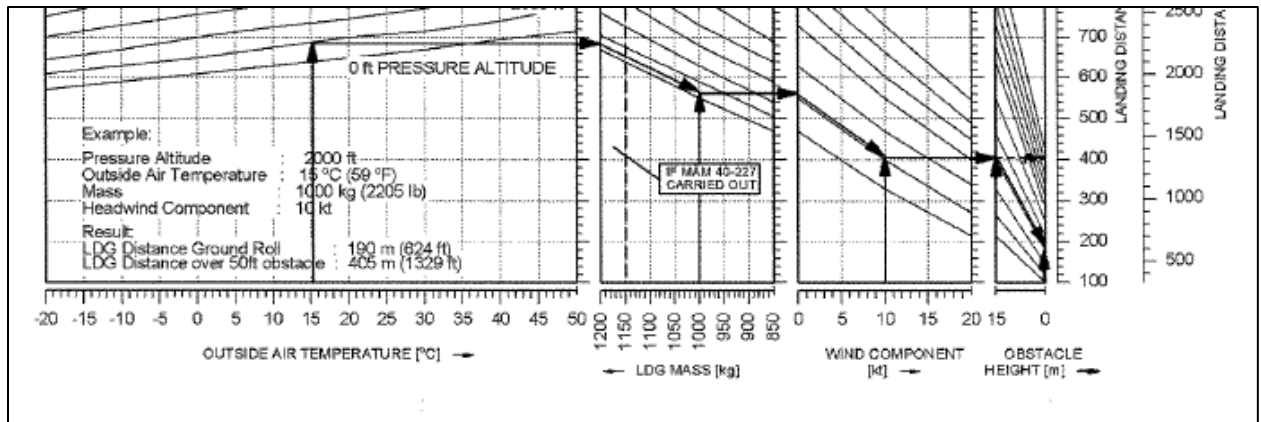


Figure 22. AFM 15 Degrees C Landing Determination.

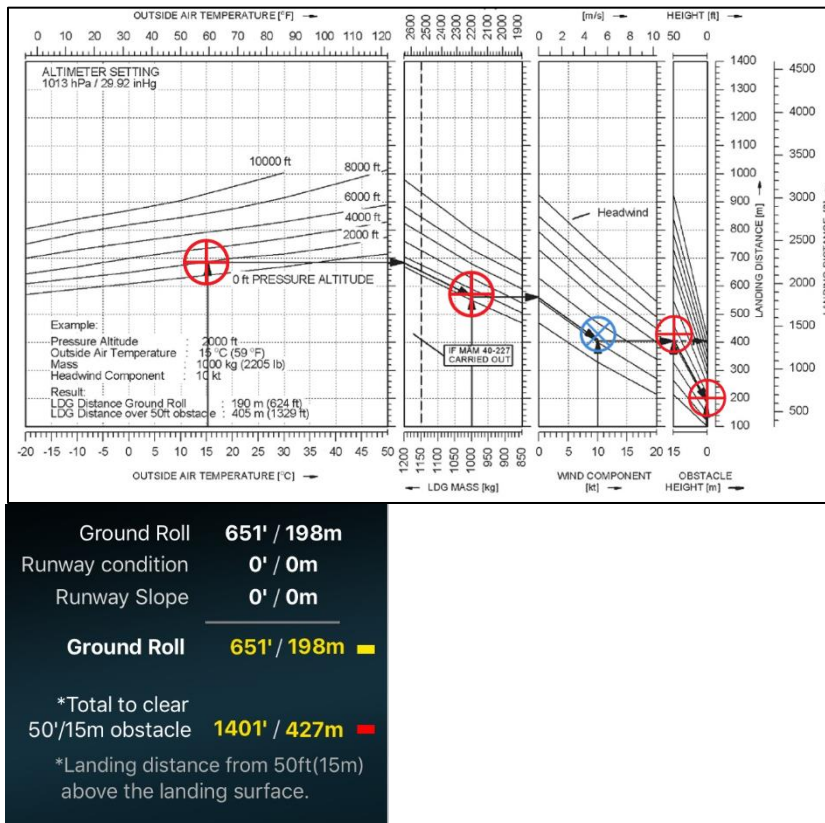


Figure 23. Gyronimo 15 Degrees C Landing Determination.

Landing Comparison 13: Temperature 30 C

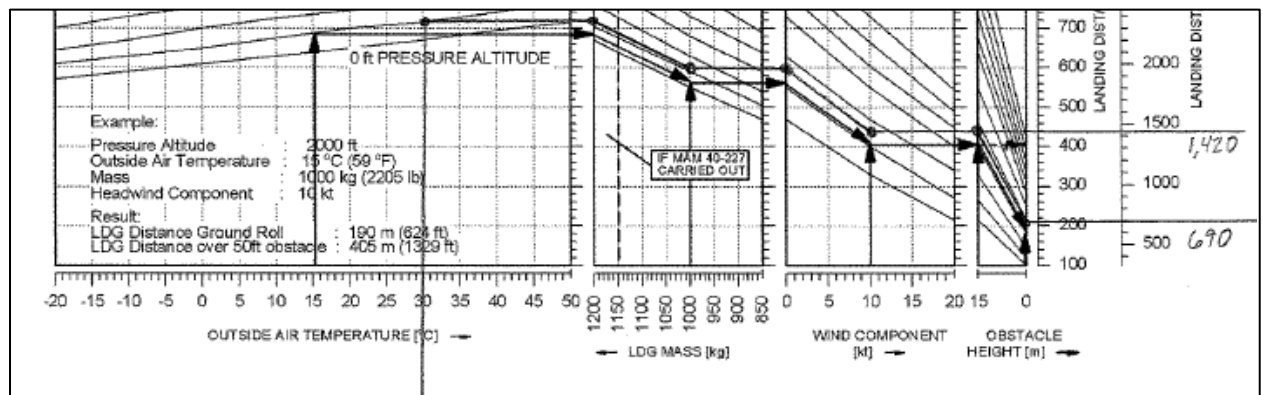


Figure 24. AFM Temperature 30 Degrees C Landing Determination

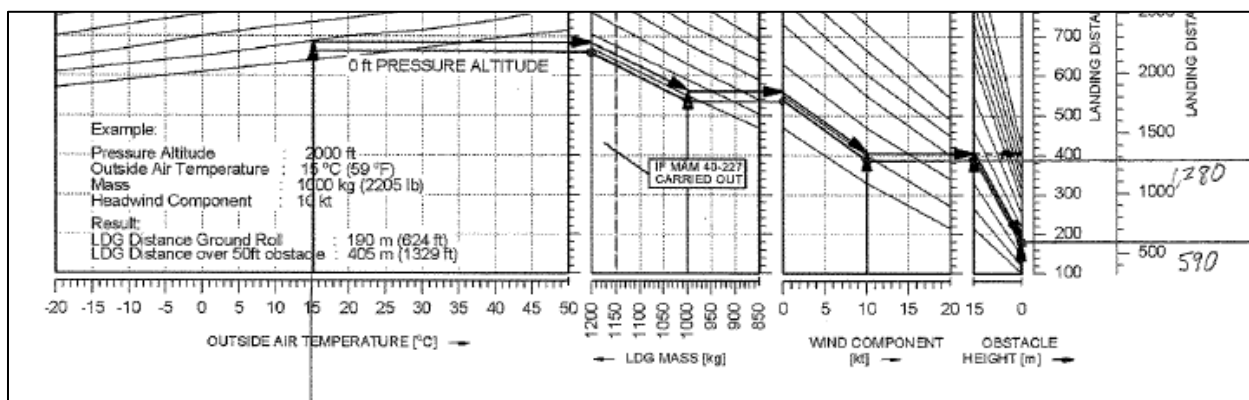


Figure 26. AFM Pressure Altitude 1,000 Feet Landing Determination

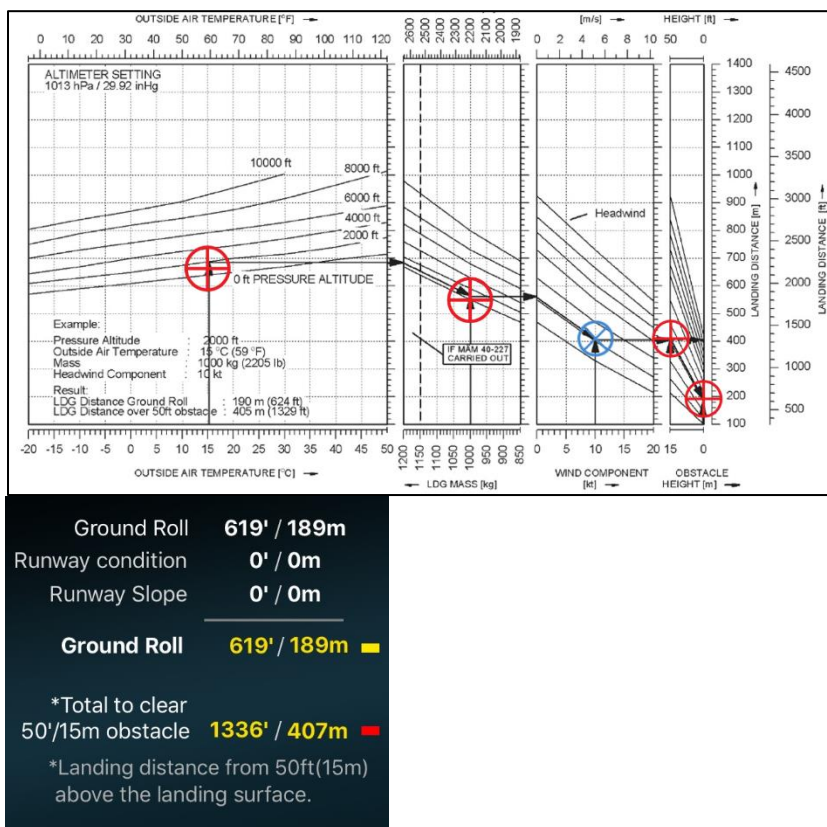


Figure 27. Gyronimo Pressure Altitude 1,000 Feet Landing Determination

Landing Comparison 15: Pressure Altitude 4,000 Feet

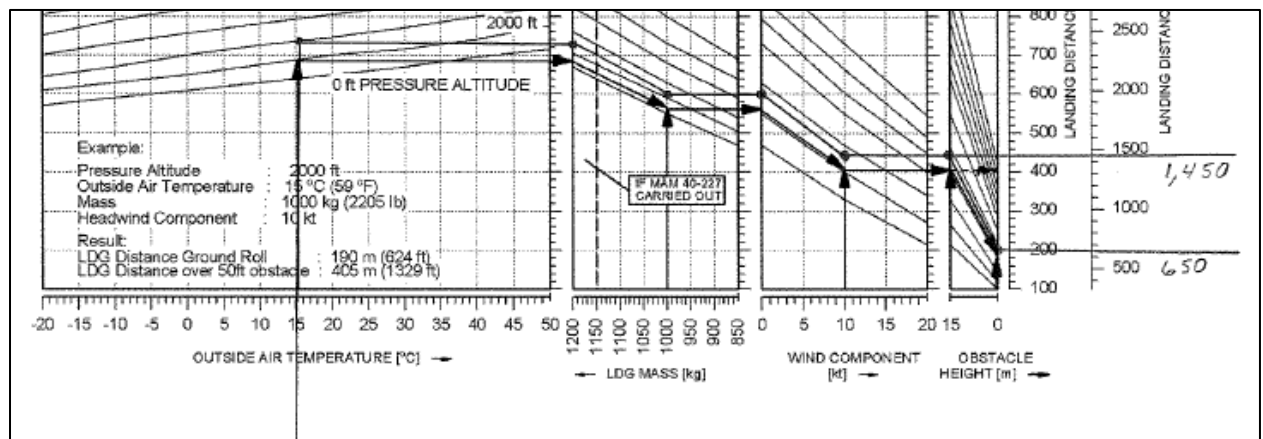


Figure 28. AFM Pressure Altitude 4,000 Feet Landing Determination



Figure 29. Gyronimo Pressure Altitude 4,000 Feet Landing Determination

Landing Comparison 16: Pressure Altitude 8,000 Feet

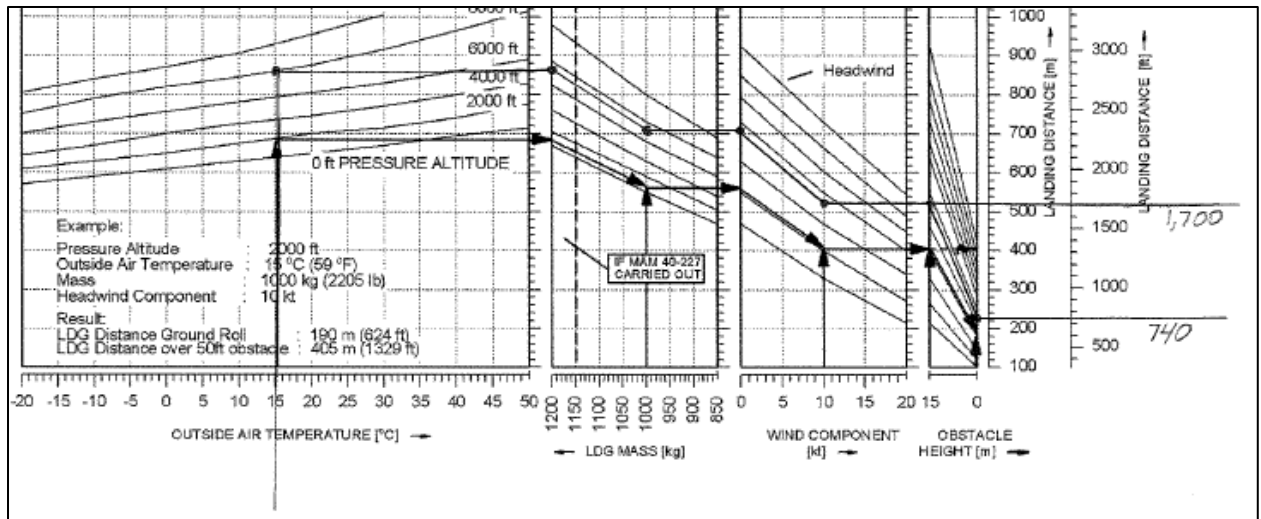
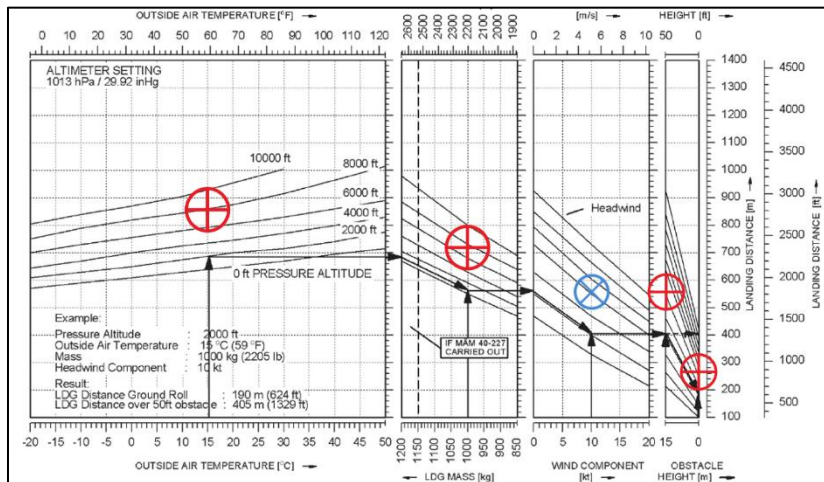


Figure 30. AFM Pressure Altitude 8,000 Feet Landing Determination



Ground Roll **862' / 263m**
 Runway condition **0' / 0m**
 Runway Slope **0' / 0m**
Ground Roll 862' / 263m
 *Total to clear
 50'/15m obstacle **1822' / 555m**
 *Landing distance from 50ft(15m)
 above the landing surface.

Figure 31. Gyronimo Pressure Altitude 8,000 Feet Landing Determination

Landing Comparison 17: Weight 2,000 Pounds

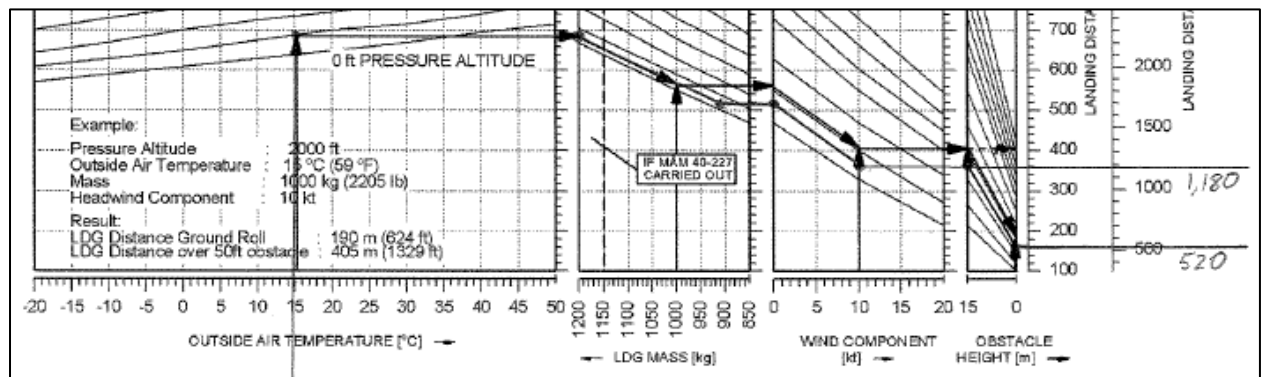


Figure 32. AFM Weight 2,000 Pounds Landing Determination

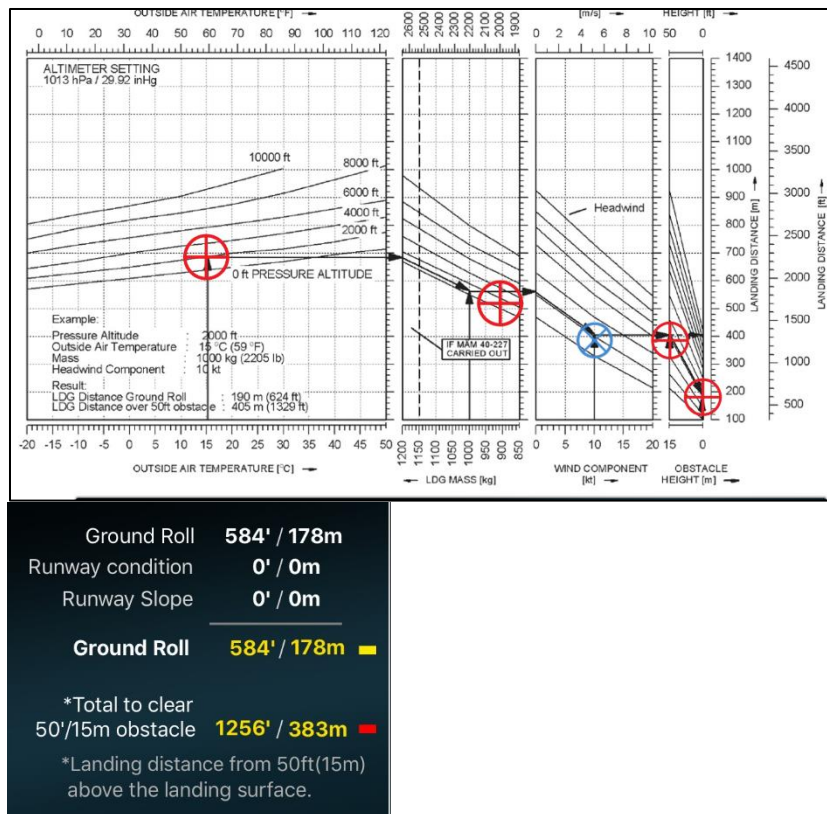


Figure 33. Gyronimo Weight 2,000 Pounds Landing Determination

Landing Comparison 18: Weight 2,400 Pounds

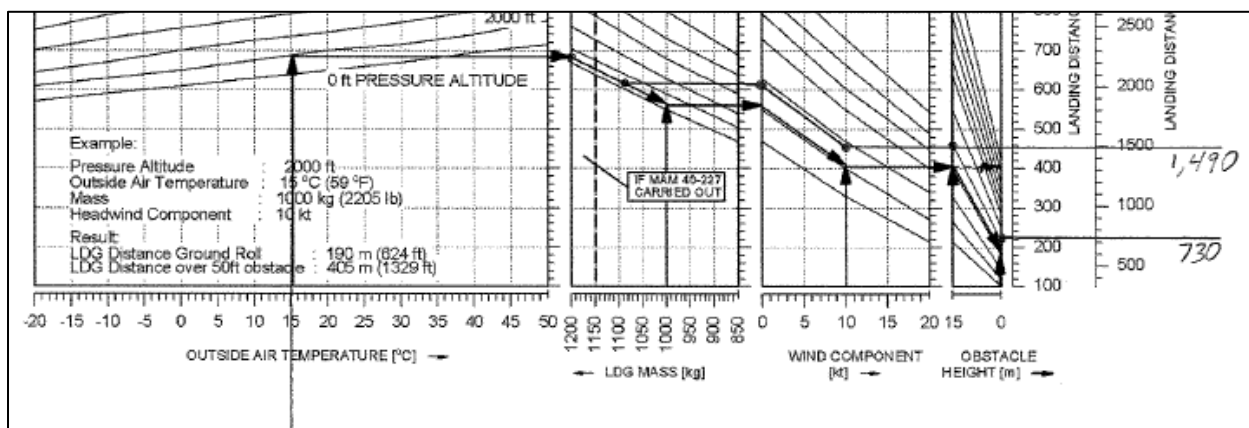
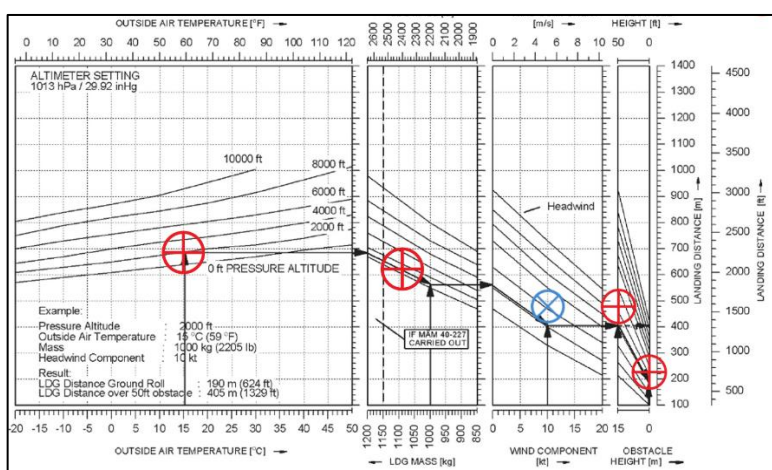


Figure 34. AFM Weight 2,400 Pounds Landing Determination



Ground Roll	732' / 223m
Runway condition	0' / 0m
Runway Slope	0' / 0m
Ground Roll	732' / 223m
*Total to clear 50'/15m obstacle	1563' / 476m
*Landing distance from 50ft(15m) above the landing surface.	

Figure 35. Gyronimo Weight 2,400 Pounds Landing Determination

Landing Comparison 19: Weight 2,600 Pounds

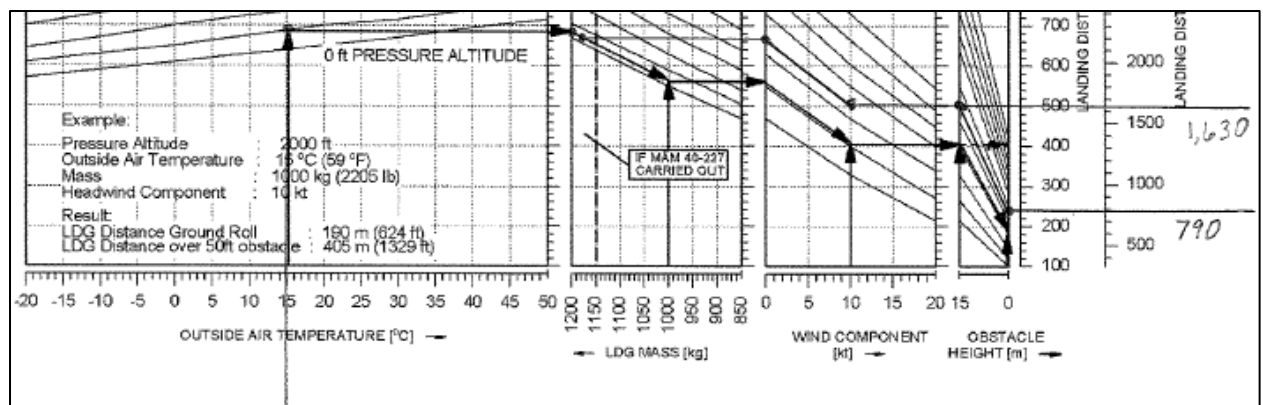


Figure 36. AFM Weight 2,600 Pounds Landing Determination

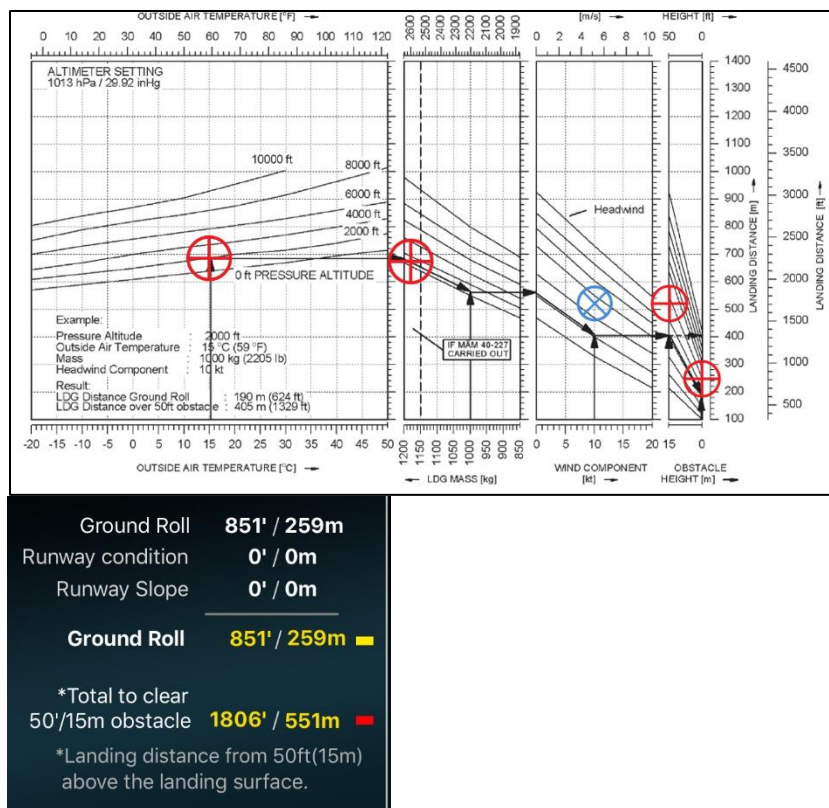


Figure 37. Gyronimo Weight 2,600 Pounds Landing Determination

Landing Comparison 20: 7 Knot Headwind

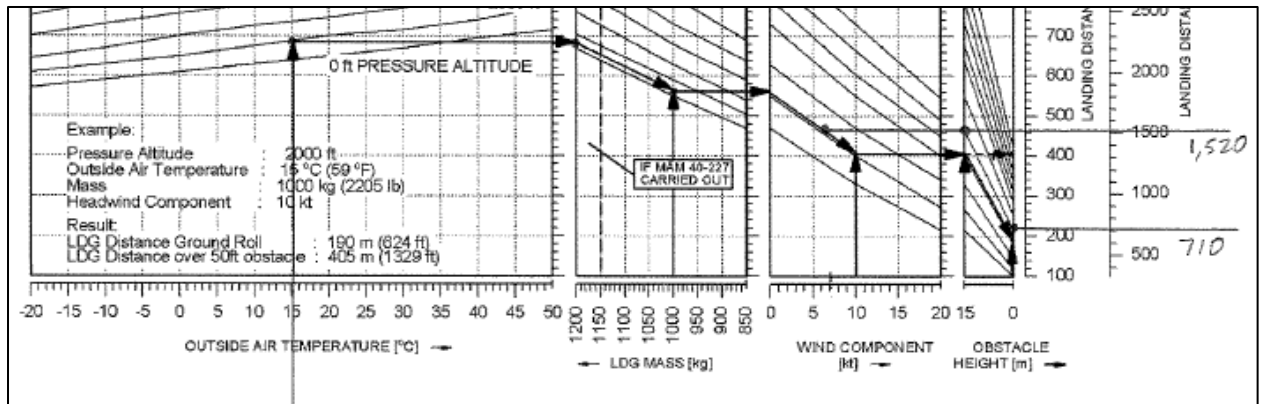


Figure 38. AFM 7 Knot Headwind Landing Determination

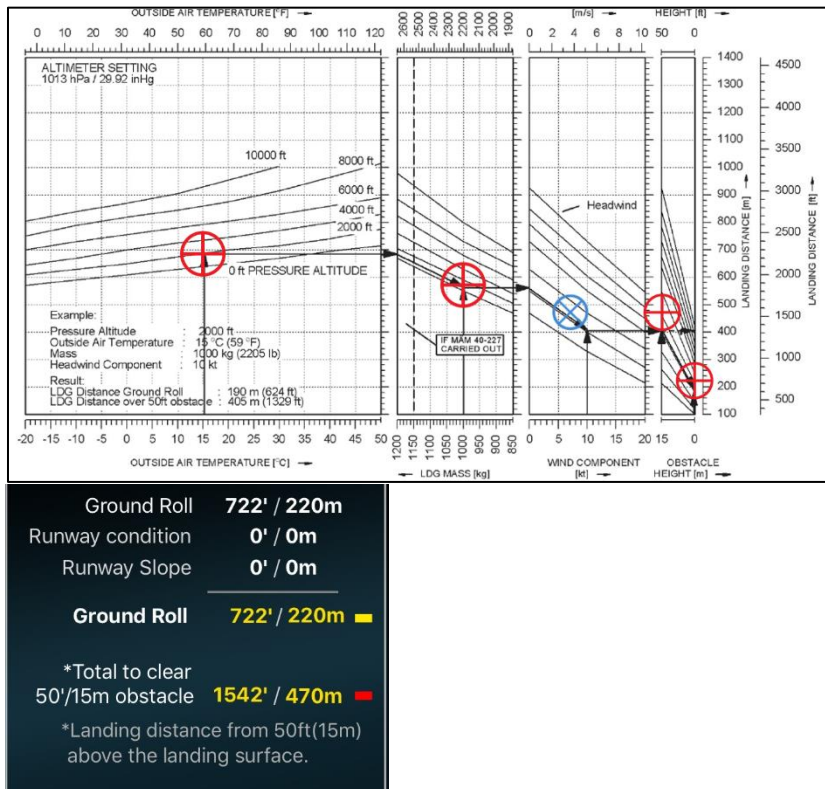


Figure 39. Gyronimo 7 Knot Headwind Landing Determination

Landing Comparison 21: 14 Knot Headwind

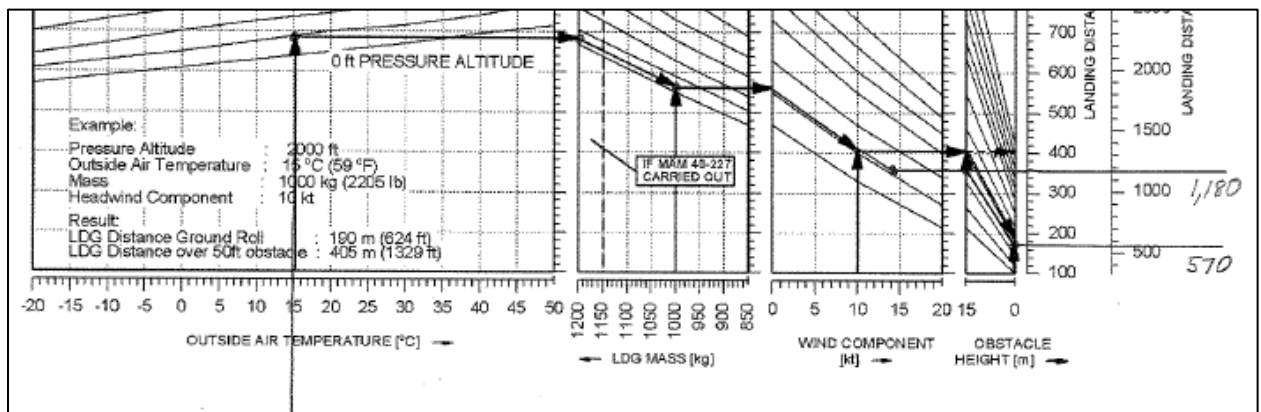


Figure 40. AFM 14 Knot Headwind Landing Determination

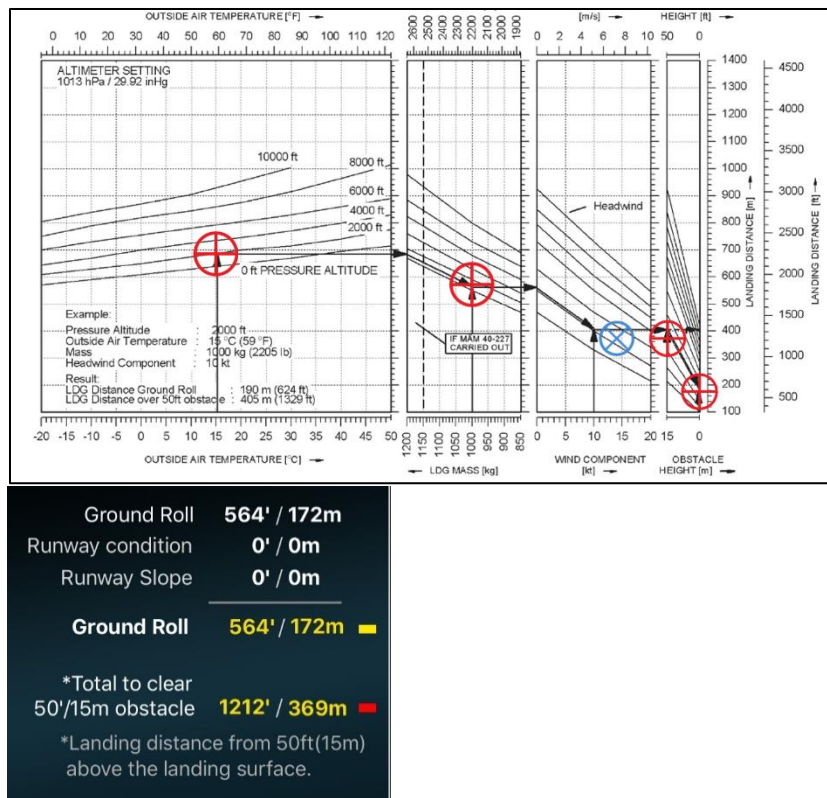


Figure 41. Gyronimo 14 Knot Headwind Landing Determination

Landing Comparison 22: 20 Knot Headwind

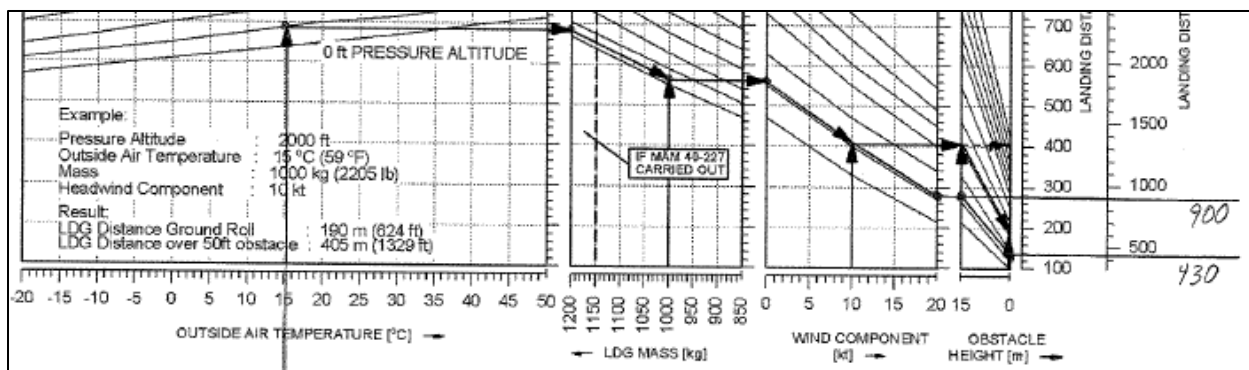


Figure 42. AFM 20 Knot Headwind Landing Determination

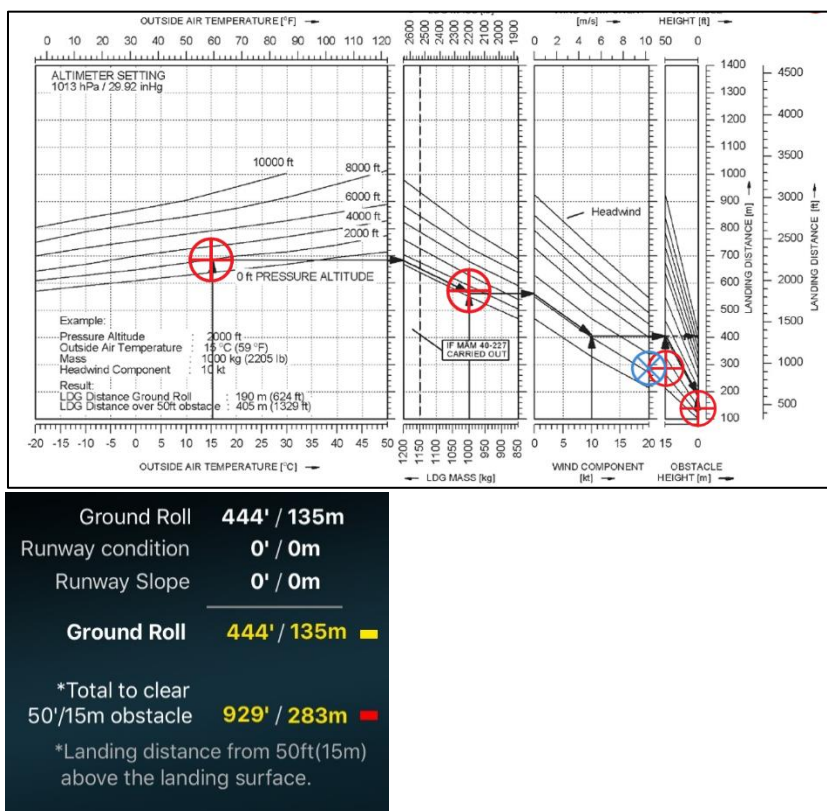


Figure 43. Gyronimo 20 Knot Headwind Landing Determination

Landing Comparison 23: Wet Grass (2-4 inches)

The default landing ground roll was 624 feet. The default landing distance over a 50-foot obstacle was 1,329 feet. According to the AFM, grass from 2-4 inches in length increases the takeoff ground roll by 15%, and if wet, an additional 10%. Thus, the AFM ground roll for wet grass was 780 feet, and the landing distance over a 50-foot obstacle under the same conditions was 1,485 feet.



Figure 44. Gyronimo Wet Grass Landing Determination

Landing Comparison 24: 2% Negative Runway Slope

The default landing ground roll was 624 feet. The default landing distance over a 50-foot obstacle was 1,329 feet. The AFM states that a 2% negative slope upon landing will increase the landing ground distance by 10%, and that this effect upon the ground roll can be greater. A 10% increase in both values yields a landing ground roll of 686 feet and landing distance over a 50-foot obstacle of 1,462 feet.



Figure 45. Gyronimo 2% Negative Runway Slope Landing Determination